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U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

ATTORNEY'S DOCKET NUMBER

GAMBRO-254

**TRANSMITTAL LETTER TO THE UNITED STATES
DESIGNATED/ELECTED OFFICE (DO/EO/US)
CONCERNING A FILING UNDER 35 U.S.C. 371**

U.S. APPLICATION NO. (If known, see 37 CFR 1.5)

09/889220

INTERNATIONAL APPLICATION NO.

PCT/IB00/00070 ✓

INTERNATIONAL FILING DATES

19 January 2000 ✓

PRIORITY DATE CLAIMED

29 January 1999 ✓

TITLE OF INVENTION FILTERS AND METHOD FOR PRODUCING FILTERS

APPLICANT(S)
FOR DO/EO/US

Jürgen DANNENMAIER, et al.

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:


1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to promptly begin national examination procedures (35 U.S.C. 371 (f)).
4. ☒ The US has been elected by the expiration of 19 months from the priority date (PCT Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c)(2))
 - a. ☐ is attached hereto (required only if not transmitted by the International Bureau).
 - b. ☒ has been communicated by the International Bureau.
 - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ An English language translation of the International Application as filed (35 U.S.C. 371 (c)(2)).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
 - a. ☐ are attached hereto (required only if not communicated by the International Bureau).
 - b. ☐ have been communicated by the International Bureau.
 - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
 - d. ☒ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)). (Executed)
10. ☐ An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).

Items 11. to 16. below concern document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98. w/PTO-1449, 10 references
12. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 & 3.31 is included.
13. ☒ A FIRST preliminary amendment.
☐ A SECOND or SUBSEQUENT preliminary amendment.
14. ☒ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information:

-Substitute Abstract
 -Marked-up Specification
 -Copy of International Application as published
 -Copy of International Preliminary Examination Report with Annexes
 -Five (5) Sheets Formal Drawings

EXPRESS MAIL LABEL NO. EL807550715US**DATE: July 12, 2001**

U.S. APPLICATION NO. (if known, see 37 CFR 1.5) <div style="font-size: 24pt; font-weight: bold; margin-left: 100px;">09/889220</div>	INTERNATIONAL APPLICATION NO. PCT/IB00/00070	ATTORNEY'S DOCKET NUMBER GAMBRO-254
17. <input checked="" type="checkbox"/> The following fees are submitted: <div style="margin-left: 20px;"> BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)): <input type="checkbox"/> Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO \$1,000.00 <input checked="" type="checkbox"/> International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO \$860.00 <input type="checkbox"/> International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO \$710.00 <input type="checkbox"/> International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) \$690.00 <input type="checkbox"/> International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) \$100.00 </div>		CALCULATIONS PTO USE ONLY <div style="border: 1px solid black; height: 100px; width: 100%;"></div>
ENTER APPROPRIATE BASIC FEE AMOUNT =		860.00
Surcharge of \$130.00 for furnishing the oath or declaration later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).		
CLAIMS	NUMBER FILED	NUMBER EXTRA
Total claims	*13 - 20 =	x \$18.00
Independent claims	2 - 3 =	x \$80.00
MULTIPLE DEPENDENT CLAIM(s) (if applicable)		+ \$270.00
TOTAL OF ABOVE CALCULATIONS =		860.00
<input type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.		
SUBTOTAL =		860.00
Processing fee of \$130.00 for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492 (f)). +		
TOTAL NATIONAL FEE =		860.00
Fee for recording the enclosed assignment (37 CFR 1.21 (h)). Assignment must be accompanied by appropriate cover sheet (37 CFR 3.28, 3.31) (\$40.00 per property). +		See Recordation Cover Sheet
TOTAL FEES ENCLOSED =		860.00
* As In Preliminary Amendment		Amount to be: Refunded <hr/> Charged
a. <input type="checkbox"/> A check in the amount of _____ to cover the above fees is enclosed. b. <input checked="" type="checkbox"/> Please charge my Deposit Account No. 12-1095 in the amount of \$ 860.00 to cover the above fees. A duplicate copy of this sheet is enclosed. c. <input checked="" type="checkbox"/> The Commissioner is hereby authorized to charge any additional fees which may be required or credit any overpayment to my Deposit Account No. 12-1095. A duplicate copy of this sheet is enclosed.		
NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.		
SEND ALL CORRESPONDENCE TO:		
Lerner, David, Littenberg, Krumholz & Mentlik, LLP 600 South Avenue West Westfield, NJ 07090 Telephone 908 654-5000 Facsimile 908 654-7866		<div style="text-align: center;">  Signature <hr/> ARNOLD H. KRUMHOLZ Name <hr/> 25,428 Registration Number </div>

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PATENT
GAMBRO 3.3-254

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of :
Jürgen DANNENMAIER, et al. :
: Group Art Unit:
International Application No. :
PCT/IB00/00070 : Examiner:
: Date: July 12, 2001
International Filing Date: :
19 January 2000 :
: For: FILTERS AND METHOD :
FOR PRODUCING FILTERS :
X

Commissioner for Patents
Washington, D.C. 20231

PRELIMINARY AMENDMENT

Sir: Preliminary to initiation of the prosecution of the above-identified pending U.S. patent application, the following amendments and remarks are respectfully submitted.

IN THE ABSTRACT

Please delete the Abstract as filed and substitute therefor the attached revised Abstract.

IN THE SPECIFICATION

Please amend the Specification in accordance with the attached revised Specification.

IN THE CLAIMS

Please cancel claims 1-12 and add new claims 13-25.

13. (NEW) A method for producing hollow fiber membrane-containing filters including a filter housing having a first portion and a second portion and including a first end and a second end, said method comprising laying a plurality of said hollow fibers in said first portion of said filter housing to form a bundle of said hollow fibers, forming said first and second portions of said filter housing into said filter housing, sealing said first and second portions of said filter housing

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together, connecting said plurality of hollow fibers together at at least one of said first and second ends of said filter housing, connecting said plurality of hollow fibers to said filter housing and simultaneously adhering said first and second portions of said filter housing together by applying a potting compound thereto, and cutting said ends of said hollow fibers at said at least one of said first and second ends whereby said plurality of hollow fibers include open ends.

14. (NEW) The method of claim 13 including sealing terminal end portions to said first and second ends of said filter housing so as to cover said ends of said hollow fiber bundle.

15. (NEW) The method of claim 13 wherein said laying of said plurality of said hollow fibers in said first portion of said filter housing comprises mounting a plurality of said first portions of said filter housing on a rotary winding wheel, continuously feeding said hollow fibers to said plurality of first portions of said filter housing as said rotary winding wheel is rotated whereby said hollow fibers are laid serially in said plurality of first portions of said filter housings, and severing said hollow fibers between said plurality of filter housings.

16. (NEW) The method of claim 15 including severing said hollow fibers between said plurality of filter housings after said sealing of said first and second portions of said filter housing together.

17. (NEW) The method of claim 13 wherein said first and second portions of said filter housing are flexibly connected to each other, and wherein said sealing of said first and second portions of said filter housing together includes swinging said first and second portions together.

18. (NEW) The method of claim 17 wherein said first and second portions of said filter housing are flexibly connected to each other by means of a film hinge.

19. (NEW) The method of claim 13 wherein said first and second portions of said filter housing are each half shell shaped, whereby said filter housing is tubular.

20. (NEW) The method of claim 14 wherein said sealing of said terminal end portions to said first and second ends of said filter housing comprises a sealing method selected from the group consisting of gluing, welding and screwing.

21. (NEW) The method of claim 13 including clamping said first and second portions of said filter housing together prior to said sealing of said first and second portions of said filter housing together.

22. (NEW) A hollow filter membrane-containing filter comprising a tubular filter having a first portion and a second portion and including a first end and a second end, a bundle of hollow fibers disposed substantially parallel to each other within said filter housing, said first and second portions of said filter housing comprising half shell shapes, and potting compound connecting together said bundle of said hollow fibers at said first end of said tubular filter housing, connecting said bundle of hollow fibers to said tubular filter housing, and connecting said first and second portions of said tubular filter housing together.

23. (NEW) The hollow filter membrane containing filter of claim 22 including a flexible connector connecting said first and second portions of said tubular filter housing together.

24. (NEW) The hollow fiber membrane containing filter of claim 23 wherein said flexible connector comprises a film hinge.

25. (NEW) The hollow fiber membrane containing filter of claim 22 including clamping members for connecting said first and second portions of said tubular filter housing together.

REMARKS

The above-noted cancellation of claims 1-12, and addition of new claims 13-25, as well as the submission of a new Abstract and revisions to the Specification, are respectfully

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submitted prior to initiation of the prosecution of this application in the U.S. Patent and Trademark Office.

The above-noted new claims are respectfully submitted in order to more clearly and appropriately claim the subject matter which applicant considers to constitute his inventive contribution. No new matter is included in these amendments. In addition, the revisions to the Abstract and Specification are submitted in order to clarify and correct the Abstract and Specification and to conform them to all of the requirements of U.S. practice. No new matter is included in these amendments.

In view of the above, it is respectfully requested that these amendments now be entered, and that prosecution on the merits of this application now be initiated. If, however, for any reason the Examiner does not believe such action can be taken, it is respectfully requested that he telephone applicant's attorney at (908) 654-5000 in order to overcome any objections which he may have.

If there are any additional charges in connection with this requested amendment, the Examiner is authorized to charge applicant's Deposit Account No. 12-1095 therefor.

Respectfully submitted,

LERNER, DAVID, LITTENBERG,
KRUMHOLZ & MENTLIK, LLP



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ABSTRACT OF THE DISCLOSURE

Methods and apparatus are disclosed for producing hollow fiber membrane-containing filters. The methods include laying a plurality of hollow fibers in a first portion of a filter housing to form a bundle, forming first and second portions into a filter housing, sealing the portions together, connecting the plurality of hollow fibers together at at least one end of the filter housing, connecting the hollow fibers to the filter housing, and simultaneously adhering the first and second portions of the filter housing together by applying a potting compound thereto, and cutting the ends of the hollow fibers at at least one end thereof, whereby the hollow fibers include open ends.

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FILTERS AND METHOD FOR PRODUCING FILTERS

FIELD OF THE INVENTION

[0001] The present invention relates to a method for producing filters with membranes of hollow fibers, for example for dialysis. More particularly, the present invention relates to a filter with membranes of hollow fibers, in which the hollow fibers are arranged as a bundle essentially parallel to one another in a tubular filter housing.

BACKGROUND OF THE INVENTION

[0002] Filters with membranes of hollow fibers are employed for the most diverse purposes in the field of dialysis. For example, such filters are utilized for haemodialysis, in which blood is passed through the inside of hollow fibers constructed with semi-permeable walls and dialysis fluid is caused to flow past the outside of the hollow fibers. During this process, diverse convection and diffusion processes take place across the walls of the hollow fibers which result in cleansing of the blood and removal of superfluous fluid. Furthermore, the electrolyte concentration in the blood is conditioned and buffers such as bicarbonate or acetate, for example, are added to the blood.

[0003] Filters of this kind are also utilized for so-called haemofiltration, in which a substitution fluid is added to the blood. The blood is fed through the hollow fibers, but no dialysis fluid flows past the outer surface of the hollow fibers. In this case, superfluous fluid, in particular water, is removed from the blood solely with the aid of a pressure difference across the membrane, i.e. the semi-permeable wall of the hollow fibers. The substitution fluid can be added to the blood either before the filter or after the filter.

[0004] The above-mentioned filters can also be used for producing the substitution fluid itself; they are then called ultrafilters. In this case, water is fed through the hollow fibers and, by means of a pressure difference across the membrane or semi-permeable walls, filtered through the same;

the water is filtered sterile by the removal of bacteria and endotoxins as well as other contamination products.

[0005] Further utilizations of the above-mentioned filters are, for example, hemodialiftration, a combination of hemodialysis andhemofiltratoin, and plasmapheresis, in which the aqueous blood plasma is filtered out of the blood and fed back into the blood after treatment. However such filters are also used for reverse osmosis.

[0006] Several processes are known for making filters with membranes. For example, a process is known from German Patent No. 28 24 898, in which several hollow fiber lengths are continuously combined to form a bundle. This bundle is then fed step-wise to a potting apparatus that pots a limited area of the fiber bundle with a potting compound so that a firm block is created that encloses the hollow fibers. In this way, by the step-wise advancing of the fiber bundle, firm areas or blocks are formed on the fiber length at predetermined distances. In the subsequent process, the fiber length is divided into individual bundles by severing each of the firm blocks through the middle. In this manner, individual bundles with firm end regions are created. These firm end regions are processed in a further step such that the fiber bundle enclosed in the firm region terminates with open ends. The thus formed fiber bundle is then put into a two-part housing. Subsequently, the two housing parts are brought together and firmly joined.

[0007] A disadvantage of this known process is the many process steps, which are expensive in terms of apparatus and cost. Furthermore, with this known process only bundles of one size for filters, or filter housings of one size, can be produced. To produce fiber bundles with different sizes for filters of different sizes the potting device must be replaced. This determines the size of the fiber bundle.

[0008] Furthermore, with this known process there is a high danger of contamination for the hollow fibers and the finished fiber bundle, as numerous processing steps are necessary and

consequently much time passes before the hollow fibers or the fiber bundle is enclosed in the housing and sealed from the environment.

[0009] This is true for the filters manufactured with this process as well as for other filters, for which a fiber bundle is fabricated in several processing steps and subsequently combined with other parts to form a filter. Examples for such filters are disclosed in German Patent Nos. 28 44 941, 28 45 002 and 28 45 003. The filters disclosed therein are each composed of several frames holding fiber bundles. The individual frames with finished fiber bundles are set on top of one another and clamped together by means of clamps, which form the housing. By adding end portions that include connections for inlet and outlet, the filter is finally completed.

[0010] Another known process consists of the feeding of hollow fibers to a winding wheel and winding these in sleeve lower parts arranged on the outer circumference thereof by turning the wheel. As soon as the desired fiber bundle thickness or fiber bundle size has been reached, the winding wheel is stopped and the sleeve upper parts are placed on the sleeve lower parts and fixed there. Subsequently, the hollow fibers are cut between the sleeves, the sleeves are removed from the winding wheel and transferred to apparatus for taking the finished fiber bundles out of the sleeves and placing them into tubular filter casings.

[0011] This known process also has the disadvantage of numerous processing steps, so that in addition to the high constructional expense and the attendant cost there also exists a high danger of contamination of the finished fiber bundle, as has been described in detail above.

[0012] From U.S. Patent No. 4,341,005, a process is known in which hollow fibers are fed to a winding wheel and are wound in first housing portions of a filter placed on the periphery of the winding wheel. If the first housing portions are full or slightly overfull, a second housing portion is

placed over each fiber filled first housing portion. The two housing portions are secured together, and the hollow fibers between the housings are then cut. The housings are removed from the winding wheel, and the hollow fibers at the ends of the housings are thereafter potted by centrifugal castings, which also permits the potting compound to join with or to adhere to the housing walls as well as to the hollow fibers. Following this potting the ends of the hollow fibers are again cut in the area of the potting compound to re-expose the hollow cores and end caps are sealed onto the housings to complete the filter.

[0013] Even if with this known process the risk for contamination of the finished fiber bundle is reduced, this known process still has the disadvantage of numerous processing steps.

[0014] From U.S. Patent No. 4,343,668, a more complex process is known, where a potting compound is applied at spaced intervals on the hollow fibers during rotation of the winding wheel. This requires a complex device leading to high constructional expenses and attendant costs.

[0015] From U.S. Patent No. 4,038,190, a process is known where hollow fibers are wound on a core, whereafter the core is placed in a housing.

[0016] This known process also has the disadvantage of numerous processing steps, so that in addition to the high constructional expenses and the attendant costs there is also a high risk for contamination of the finished fiber bundle as has been described in detail above.

[0017] In view of this background it is an object of the present invention to provide a method for producing filters with membranes of hollow fibers, for example for dialysis, whereby filters of any desired size can inexpensively and easily be reliably manufactured without excessive outlay, and with which the danger of contamination of the fiber bundle during fabrication of the filter is reduced.

[0018] A further object of the present invention is to provide a filter with membranes of hollow fibers, in which the hollow fibers are arranged essentially parallel to one another as a bundle in a tubular filter housing and that can be easily, inexpensively and reliably fabricated without excessive outlay.

SUMMARY OF THE INVENTION

[0019] In accordance with the present invention, these and other objects have now been realized by the invention of a method for producing hollow fiber membrane-containing filters including a filter housing having a first portion and a second portion and including a first end and a second end, the method comprising laying a plurality of the hollow fibers in the first portion of the filter housing to form a bundle of the hollow fibers, forming the first and second portions of the filter housing into the filter housing, sealing the first and second portions of the filter housing together, connecting the plurality of hollow fibers together at at least one of the first and second ends of the filter housing, connecting the plurality of hollow fibers to the filter housing and simultaneously adhering the first and second portions of the filter housing together by applying a potting compound thereto, and cutting the ends of the hollow fibers at the at least one of the first and second ends whereby the plurality of hollow fibers include open ends. In a preferred embodiment, the method includes sealing terminal end portions to the first and second ends of the filter housing so as to cover the ends of the hollow fiber bundle.

[0020] In accordance with one embodiment of the method of the present invention, the laying of the plurality of the hollow fibers in the first portion of the filter housing comprises mounting a plurality of the first portions of the filter housing on a rotary winding wheel, continuously feeding the hollow fibers to the plurality of first portions of the filter housing as the rotary winding wheel is rotated, whereby the hollow fibers are laid serially in the plurality of first

portions of the filter housings, and severing the hollow fibers between the plurality of filter housings. In a preferred embodiment, the method includes severing the hollow fibers between the plurality of filter housings after the sealing of the first and second portions of the filter housing together.

[0021] In accordance with one embodiment of the method of the present invention, the first and second portions of the filter housing are flexibly connected to each other, and the sealing of the first and second portions of the filter housing together includes swinging the first and second portions together. In a preferred embodiment, the first and second portions of the filter housing are flexibly connected to each other by means of a film hinge.

[0022] In accordance with another embodiment of the method of the present invention, the first and second portions of the filter housing are each half shell shaped, whereby the filter housing is tubular.

[0023] In accordance with another embodiment of the method of the present invention, the sealing of the terminal end portions to the first and second ends of the filter housing comprises a sealing method such as gluing, welding or screwing.

[0024] In accordance with another embodiment of the method of the present invention, the method includes clamping the first and second portions of the filter housing together prior to sealing of the first and second portions of the filter housing together.

[0025] In accordance with the present invention, a hollow filter membrane-containing filter is provided comprising a tubular filter having a first portion and a second portion and including a first end and a second end, a bundle of hollow fibers disposed substantially parallel to each other within the filter housing, the first and second portions of the filter housing comprising half shell shapes, and potting compound connecting together the bundle of the hollow fibers

at the first end of the tubular filter housing, connecting the bundle of hollow fibers to the tubular filter housing, and connecting the first and second portions of the tubular filter housing together. In a preferred embodiment, the hollow filter membrane includes a flexible connector connecting the first and second portions of the tubular filter housing together. In one embodiment the flexible connector comprises a film hinge.

[0026] In accordance with one embodiment of the hollow fiber membrane containing filter, the filter includes clamping members for connecting the first and second portions of the tubular filter housing together.

[0027] The objects of the present invention are achieved by means of a method wherein hollow fibers are laid one after the other in a first housing portion to form a bundle, subsequently a second housing portion is placed on the first housing portion to form a filter housing, the housing portions are joined in a sealed fashion, the hollow fibers are joined in a sealed fashion both to each other and to the filter housing at least at one end by means of a potting compound, and the potted fiber ends are cut so that the hollow fibers terminate with open ends, whereby the first housing portion and the second housing portion are adhered together by means of the potting compound when the hollow fiber ends are potted.

[0028] This obviates an additional processing step for providing a sealed joint between both housing portions, so that the method as a whole becomes simple and less expensive. Polyurethane can be used as a potting compound, for example. This is particularly favorable when polycarbonate or ABS (Acrylnitril-Butadiene-Styrol copolymer) is used as the material for the housing portions.

[0029] The advantageous method for adhering the two housing portions by means of the potting compound can also be reliably employed when the hollow fibers are to be connected in a sealed fashion to one another and to the housing portions or the filter housing only at one end. In this case, for example,

the potting compound can be fed in a suitable manner to the contact surfaces of the housing portions and to the ends of the hollow fibers that are to be potted.

[0030] According to a preferred further embodiment, the hollow fiber bundle ends are each covered with a terminating part that is connected to the filter housing in a sealed fashion.

[0031] With this method it is possible to manufacture filters of any desired size simply and reliably, while at the same time, the danger of contamination is significantly reduced. The hollow fibers are laid one after the other in the filter housing to form a bundle, and the filter housing is closed directly after completing the fiber bundle. The fiber bundle is thus exposed to the surrounding atmosphere for only a short time, so that the risk of contamination of the fiber bundle is reduced. Also the risk of contamination of individual hollow fibers during the formation of the fiber bundle is reduced, as they are laid directly in the filter housing, and is not required to pass through several processing stages before arriving in the filter housing.

[0032] Laying the hollow fibers one after another in the filter housing has the further advantage that filters of any desired size can be produced easily and without replacing tools. Depending on the filter size, and thus the required size of the fiber bundle, only the required number of hollow fibers need be placed in the corresponding filter housing and the latter subsequently closed. In this manner, filters of any desired size, i.e. with any desired membrane surface, can be fabricated easily and with little outlay. In particular, it is no longer necessary to provide different tools for each of the different fiber bundle sizes.

[0033] The method according to the present invention is further simplified when, in accordance with a particularly preferred embodiment, the hollow fibers are fed continuously to a rotary winding wheel, on the outer circumference of which first housing portions are arranged. The housing portions are

arranged such that the hollow fibers can be laid in these first housing portions as the wheel rotates, while after placing the second housing portions on the first housing portions the hollow fibers are severed between the filter housings.

[0034] In this manner, the filters can be produced in a particularly simple fashion. The hollow fibers are continually wound into the housing portions arranged on the outer circumference of the winding wheel until the desired fiber bundle thickness, and therefore the desired membrane surface is obtained. It is advantageous that several filters or fiber bundles can be made simultaneously in one process step, namely the winding of the hollow fibers on the winding wheel. The number of generated filters or fiber bundles depends, *inter alia*, on the diameter of the winding wheel. A winding wheel with a large diameter has a larger outer circumference on which more housing portions can be arranged one behind the other. Likewise, the width of the winding wheel determines the number of filters or fiber bundles that can be made in one processing stage. If the winding wheel is wide enough, two or more housing portions can be laid side by side, so that two or more rows of housing portions arranged one after another into which the hollow fibers can be wound are provided on the outer circumference. This all contributes to providing a simple and inexpensive method.

[0035] It is furthermore advantageous when, in accordance with another embodiment, the second housing portion is flexibly joined to the first housing portion so that it need only be swung onto the first housing portion. For example, the first and second housing portions could be flexibly joined by means of a film hinge. This simplifies and facilitates the manufacture of the filter housing itself, since the first and second housing portions can be formed together as one part.

[0036] A further improvement of the method of the present invention is obtained when both housing portions are formed half-shell-shaped, and the second half-shell-shaped housing

portion is placed on the first half-shell-shaped housing portion to form a tubular filter housing. This facilitates on the one hand the winding of the hollow fibers in the first housing portion, as the half-shell shape of the first housing portion causes the hollow fibers to be centered as they are wound. On the other hand, the fiber bundle with the hollow fibers arranged essentially in parallel is surrounded in a manner adapted to its contours by the finished tubular filter housing. Thus, no superfluous space is present around the fiber bundle that could accommodate unnecessarily large amounts of dialysis fluid, for example. Furthermore, the fiber bundle is supported from the outside so that the individual hollow fibers are securely held in the bundle. Mechanical damage to the hollow fibers is consequently avoided.

[0037] The terminating parts covering the hollow fiber ends can be connected to the filter housing in any desired manner, provided that a sealed and reliable joint is obtained. However, it is advantageous when the terminating parts are glued or welded or are screwed on to the filter housing. In this manner, a simple, secure and reliable connection between terminating parts and filter housing is obtained.

[0038] The objects of the present invention are also achieved by means of an apparatus, wherein the tubular filter housing is composed of two half-shells, and wherein the two half-shells are adhered together by means of the potting compound.

[0039] In this manner, the filters can be made simply and inexpensively without excessive outlay, as the hollow fibers can be laid one after the other in a first half-shell. Depending on the desired filter size or fiber bundle size that determines the membrane surface, the required number of hollow fibers can be laid in the filter housing. The thus formed fiber bundle can then be covered directly by the second half-shell, that is placed on the first half-shell, so that, on the one hand, damage to the hollow fibers, or the fiber bundle, by

external forces is avoided, and on the other hand, the risk of contamination is reduced.

[0040] In accordance with a preferred embodiment, it is advantageously provided that the tubular filter housing is composed of two flexibly connected half-shells, the two half-shells being preferably flexibly connected by means of a film hinge. In this manner, the manufacture of the filter housing per se is inter alia simplified, because the first and second half-shells are formed as one piece and can be fabricated together. After laying the hollow fibers in the first half-shell, the second half-shell need only be swung onto the first half-shell to form the tubular housing for the filter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0041] Further features and advantages of the present invention will be described in more detail with reference to the following detailed description, which, in turn, refers to the enclosed drawings, wherein:

[0042] Fig. 1 is a side, elevational, schematic view of a winding wheel used in the method of the present invention;

[0043] Fig. 2 is a side, perspective view of an open filter housing;

[0044] Fig. 3 is a top, plane view of an open filter housing with a partially shown fiber bundle;

[0045] Fig. 4 is a front, elevational, sectional view through the filter housing of Fig. 3 taken along line A-A thereof;

[0046] Fig. 5 is a side, perspective view of a filter housing connected in a sealed fashion by means of ultrasound welding, with terminating parts;

[0047] Fig. 6 is a top, plan view of an open filter housing for connecting both housing portions in a sealed fashion by means of the potting compound; and

[0048] Fig. 7 is a side perspective view of a filter housing with terminating parts joined in a sealed manner by means of the potting compound of the present invention.

DETAILED DESCRIPTION

[0049] Referring to the drawings, Fig. 1 shows a side view of a winding wheel 9. On the outer circumference of the winding wheel 9 several filter housings 13 are arranged in such a way that hollow fibers 1 can be wound in the filter housing 13. The hollow fibers 1 are fed from a supply roller 3 to a distributor apparatus 5, and from there further to the winding wheel 9. It is to be noted at this point that the hollow fibers could also be supplied to the distributor apparatus directly from a production machine, or spinning machine.

[0050] Several distributor rollers 7 are arranged on the distributor apparatus 5 and each feeds individual hollow fibers 1 to the filter housings 13 arranged on the winding wheel 9. The distributor rollers 7 are movable in their longitudinal axes and are controlled such that the individual hollow fibers 1 are placed in the filter housings 13 offset relative to one another and distributed across the whole housing width. The hollow fibers 1 are unwound from the supply roller 3 and wound on the winding wheel 9, or rather in the filter housings 13 arranged on the outer circumference of the winding wheel, as the winding wheel 9 is turned as indicated by the arrow 11. A tension roller 15 is disposed between the supply roller 3 and the distributor apparatus 5 and holds the hollow fibers 1 under a certain tension to enable the controlled deposit or winding of the hollow fibers 1 in the filter housings 13 on the winding wheel. The tension can be applied to the tension roller 15, or the hollow fibers 1, as indicated by the arrow at 15 using spring force or weight.

[0051] The individual distributor rollers 7 can also each feed two or more hollow fibers 1 to the filter housings 13 disposed on the winding wheel 9. In this case, the hollow fibers 1 supplied to the filter housings 13 by the different distributor rollers 7 are placed in the filter housings 13 displaced in groups relative to one another.

[0052] Fig. 2 shows a perspective view of an open filter housing 13. The filter housing 13 consists of a first half-shell-shaped housing portion 21 and a second half-shell-shaped housing portion 23, that are flexibly connected with one another by means of a film hinge 27. The first housing portion 21 comprises a connection 25 and a weld or adhesion strip 33 on the longitudinal side opposing the film hinge 27. The second housing portion 23 likewise comprises a weld or adhesion strip 35 on the longitudinal side opposing the film hinge 27. Several clamp stubs 29 are disposed on the weld or adhesion strip 33 of the first housing portion 21 and are constructed such that they can engage with correspondingly constructed apertures 31 on the weld or adhesion strip 35 of the second housing portion 23. To close the filter housing 13, the second housing portion 23 is pivoted onto the first housing portion 21 by means of the film hinge 27, so that the clamp stubs 29 latch into the apertures 31 and affix the first and second housing portions, 21 and 23, together, with the weld and adhesion strips, 33 and 35, lying on top of one another. These are then joined in a sealed fashion by welding or gluing, as will be described later in more detail.

[0053] However, the sealed connection of the two housing portions 21 and 23 occurs only when the desired number of hollow fibers 1 has been laid in the first housing portion 21 and forms the desired bundle. To permit this, the filter housing 13 is disposed on the outer circumference of the winding wheel 9 (Fig. 1) in the open state shown in Fig. 2 in such a manner that at least the inside of the first housing portion 21 is directed outwardly. In this way, the hollow fibers 1 can be wound into the filter housing 13 as described with reference to Fig. 1.

[0054] Fig. 3 shows a plan view of a filter housing 13, wherein a hollow fiber bundle 41 arranged in the first housing portion 21 is partially depicted. The filter housing 13 corresponds essentially to the filter housing 13 shown in Fig. 2 and described with reference to Fig. 2, so a renewed detail

description can be dispensed with. In contrast to the filter housing 13 shown in Fig. 2, the clamp stubs 43 are not arranged on the weld or adhesion strip 33, but rather on the outer edge of same. Also, the apertures 45 are not arranged in the weld or adhesion strip 35 of the second housing portion 23, but likewise on the outer edge of same.

[0055] It should be noted at this stage that the connector 25 arranged on the first housing portion 21 need not necessarily be disposed there. For example, the connector 25 could also be arranged on the terminating part that is described below in detail. Likewise, the connector 25 could be arranged on the second housing portion 23, or two or more connectors 25 could be provided, which may be arranged on the first or second housing portions, 21 and 23, or on the terminating parts still to be described, as desired.

[0056] As can be seen well in Fig. 3, the hollow fiber bundle 41 lies with hollow fibers 1 arranged essentially in parallel in the half-shell-shaped first housing portion 21 and fills the latter substantially completely. This can also be seen well from Fig. 4, which shows a section through the filter housing 13 along line A-A in Fig. 3. The hollow fiber bundle 41 fills the cross section essentially fully, so that when the filter housing 13 is closed, that is, when the second housing portion 23 has been swung onto the first housing portion 21, it is supported mechanically by the filter housing 13. However it is not compressed by the filter housing 13; the hollow fibers are still separated from one another by a certain space or play.

[0057] Fig. 5 shows a perspective view of a filter housing 13 in the closed state with mounted terminating parts 47. The terminating parts 47 that are placed, respectively, on the ends of the tubular filter housing each comprise a further connector 49. As for the connectors 25, the connectors 49 can be of any desired structure and, for example, can comprise a screw thread for connecting a conduit. The terminating parts 47 themselves can be placed on the filter housing in any

desired manner, for example, they can be screwed on or be connected in a sealed fashion to the filter housing by welding or adhesion. In the embodiment illustrated, the first housing portion 21 and the second housing portion 23 of the filter housing 13 are connected together in a sealed manner by ultrasonic welding of the weld strip 33 on the first housing portion 21 to the weld strip 35 on the second housing portion 23.

[0058] This is only one possibility for connecting the first and second housing portions, 21 and 23, in a sealed fashion. Another possibility that was mentioned above, is the gluing together of the first and second housing portions, 21 and 23, by means of the potting compound when potting the hollow fibers. A plan view of a correspondingly formed filter housing 13 is shown in Fig. 6.

[0059] To simplify the description, like parts are provided with like reference numerals. In contrast to the above described filter housings 13, the first and second housing portions, 21 and 23, each comprise a potting strip 51 on their longitudinal sides opposing the film hinge 27. In their central areas, the potting strips 51 each have a potting aperture 53 and, at their ends, an outlet aperture 57. A potting channel 55 extends from the potting aperture 53 on both sides towards the outlet apertures 57. Clamping means 59 are arranged in the potting strip 51 on the first housing portion 21 and are formed such that they engage with corresponding clamping means 61 arranged in the potting strip 51 of the second housing portion 23. These clamping means, 59 and 61, engage in one another and hold the filter housing 13 in a closed position when the second housing portion 23 is swung onto the first housing 21 by means of the film hinge 27.

[0060] In this closed state shown in Fig. 7, the potting strips 51 of the first and second housing portions, 21 and 23, lie against one another so that the potting channel 55 is closed. If a potting compound, for example polyurethane, is now poured into the potting aperture 53, it will flow through

the potting channel 55 towards the outlet apertures 57 and will exit there through these outlet apertures 57 into the interior of the filter housing 13, to pot the hollow fiber ends. The flow movement of the potting compound towards the outlet apertures 57 and thus the potting of the hollow fiber ends can, for example, be effectively assisted when the filter housing 13 is rotated to generate centrifugal forces acting in the direction of the ends of the filter housing 13.

[0061] After hardening, the potting compound remaining in the potting channel 55 sticks together the connected housing portions, 21 and 23, that are affixed by means of the clamping means, 59 and 61, and seals the joint at the same time. A filter housing 13 made in this way is shown in perspective view in Fig. 7. Here again, like parts are provided with like reference numerals to simplify the description. Here the combined potting strips 51 with the potting aperture 53 in the centre are easily identifiable.

[0062] Although the invention herein has been described with reference to particular embodiments, it is to be understood that these embodiments are merely illustrative of the principles and applications of the present invention. It is therefore to be understood that numerous modifications may be made to the illustrative embodiments and that other arrangements may be devised without departing from the spirit and scope of the present invention as defined by the appended claims.

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FILTERS AND METHOD FOR PRODUCING FILTERS

FIELD OF THE INVENTION

[0001] The present invention ~~concerns~~ relates to a method for producing filters with membranes of hollow fibrefibers, for example for dialysis. ~~It further~~ More particularly, the present invention relates to a filter with membranes of hollow fibrefibers, in which the hollow fibrefibers are arranged as a bundle essentially parallel to one another in a tubular filter housing.

TECHNICAL BACKGROUND OF THE INVENTION

[0002] Filters with membranes of hollow fibrefibers are employed for the most diverse purposes in the field of dialysis. For example, such filters are ~~utilise~~ utilized for haemodialysis, in which blood is passed through the inside of hollow fibrefibers constructed with semi-permeable walls and dialysis fluid is caused to flow past the outside of the hollow fibrefibers. During this process, diverse convection and diffusion processes take place across the walls of the hollow fibrefibers ~~that~~ which result in a cleansing of the blood and removal of superfluous fluid. Furthermore, the electrolyte concentration in the blood is conditioned and buffers such as bicarbonate or acetate, for example, are added to the blood.

[0003] Filters of this kind are also ~~utilise~~ utilized for so-called haemofiltration, in which a substitution fluid is added to the blood. The blood is fed through the hollow fibrefibers, but no dialysis fluid flows past the outer surface of the hollow fibrefibers. In this case, superfluous fluid, in particular water, is removed from the blood solely with the aid of a pressure difference across the membrane, i.e. the semi-permeable wall of the hollow fibrefibers. The substitution fluid can be added to the blood either before the filter or after the filter.

[0004] The above-mentioned filters can also be used for producing the substitution fluid itself; they are then called ultrafilters. In this case, water is fed through the hollow

fibrefibers and, by means of a pressure difference across the membrane or semi-permeable walls, filtered through the same; the water is filtered sterile by the removal of bacteria and endotoxins as well as other contamination products.

[0005] Further ~~utilisations~~utilizations of the above-mentioned filters are, for example, ~~haemodiafiltration~~hemodialiftration, a combination of ~~haemodialysis~~hemodialysis and ~~haemofiltration~~hemofiltratoin, and plasmapheresis, in which the aqueous blood plasma is filtered out of the blood and fed back into the blood after treatment. However such filters are also used for reverse osmosis.

[0006] Several processes are known for making filters with membranes. For example, a process is known from ~~DE-C~~German Patent No. 28 24 898, in which several hollow fibrefiber lengths are continuously combined to form a bundle. This bundle is then fed step-wise to a potting apparatus that pots a limited area of the fibrefiber bundle with a potting compound so that a firm block is created that encloses the hollow fibrefibers. In this way, by the step-wise advancing of the fibrefiber bundle, firm areas or blocks are formed on the fibrefiber length at predetermined distances. In the subsequent process, the fibrefiber length is divided into individual bundles by severing each of the firm blocks through the middle. In this ~~way~~manner, individual bundles with firm end regions are created. These firm end regions are processed in a further step such that the fibrefiber bundle enclosed in the firm region terminates with open ends. The thus formed fibrefiber bundle is then put into a two-part housing. Subsequently, the two housing parts are brought together and firmly joined.

[0007] A disadvantage of this known process is ~~inter alia~~ the many process steps, which are expensive in terms of apparatus and cost. Furthermore, with this known process only bundles of one size for filters, or filter housings of one size, can be produced. To produce fibrefiber bundles with

different sizes for filters of different sizes the potting device must be replaced. This determines the size of the fibrefiber bundle.

[0008] Furthermore, with this known process there is a high danger of contamination for the hollow fibrefibers and the finished fibrefiber bundle, as numerous processing steps are necessary and consequently much time passes before the hollow fibrefibers or the fibrefiber bundle is enclosed in the housing and sealed from the environment.

[0009] This is true for the filters manufactured with this process as well as for other filters, for which a fibrefiber bundle is fabricated in several processing steps and subsequently combined with other parts to form a filter. Examples for such filters are disclosed in DE-A-German Patent Nos. 28 44 941, DE-A-28 45 002 and DE-A-28 45 003. The filters disclosed therein are each composed of several frames holding fibrefiber bundles. The individual frames with finished fibrefiber bundles are set on top of one another and clamped together by means of clamps, which form the housing. By adding end portions that include connections for inlet and outlet, the filter is finally completed.

[0010] Another known process consists of the feeding of hollow fibrefibers to a winding wheel and winding these in sleeve lower parts arranged on the outer circumference thereof by turning the wheel. As soon as the desired fibrefiber bundle thickness or fibrefiber bundle size has been reached, the winding wheel is stopped and the sleeve upper parts are placed on the sleeve lower parts and fixed there. Subsequently, the hollow fibrefibers are cut between the sleeves, the sleeves are removed from the winding wheel and transferred to an apparatus for taking the finished fibrefiber bundles out of the sleeves and placing them into tubular filter casings.

[0011] This known process also has the disadvantage of numerous processing steps, so that in addition to the high constructional expense and the attendant cost there also

exists a high danger of contamination of the finished fibrefiber bundle, as has been described in detail above.

[0012] From US 4 341 005 U.S. Patent No. 4,341,005, a process is known where in which hollow fibers are fed to a winding wheel and are wound in first housing portions of a filter placed on the periphery of the winding wheel. If the first housing portions are full or slightly overfull, a second housing portion is placed over each fiber filled first housing portion. The two housing portions are secured together, and the hollow fibers between the housings are then cut. The housings are removed from the winding wheel, and the hollow fibers at the ends of the housings are thereafter potted by centrifugal castings, which also permits the potting compound to join with or to adhere to the housing walls as well as to the hollow fibers. Following this potting the ends of the hollow fibers are again cut in the area of the potting compound to re-expose the hollow ~~core~~ cores and end caps are sealed onto the housings to complete the filter.

[0013] Even if with this known process the risk for contamination of the finished fiber bundle is reduced, this known process still has the disadvantage of numerous processing steps.

[0014] From US 4 343 668 U.S. Patent No. 4,343,668, a more complex process is known, where a potting compound is applied at spaced intervalls on the hollow fibers during rotation of the winding wheel. This requires a complex and ~~complicated~~ device leading to high constructional expenses and attendant costs.

[0015] From US 4 038 190 U.S. Patent No. 4,038,190, a process is known where hollow fibers are wound on a core, whereafter the core is placed in a housing.

[0016] This known process also has the disadvantage of numerous processing steps, so that in addition to the high constructional expenses and the attendant costs there is also a high risk for contamination of the finished fiber bundle as has been described in detail above.

DESCRIPTION OF THE INVENTION

[0017] In view of this background it is ~~thus the~~ an object of the present invention to provide a method for producing filters with membranes of hollow ~~fibrefibers~~, for example for dialysis, whereby filters of any desired size can inexpensively and easily be reliably manufactured without excessive outlay, and with which the danger of contamination of the ~~fibrefiber~~ bundle during fabrication of the filter is reduced.

[0018] A further object of the present invention is to provide a filter with membranes of hollow ~~fibrefibers~~, in which the hollow ~~fibrefibers~~ are arranged essentially parallel to one another as a bundle in a tubular filter housing and that can be easily, inexpensively and reliably fabricated without excessive outlay.

SUMMARY OF THE INVENTION

[0019] In accordance with the present invention, these and other objects have now been realized by the invention of a method for producing hollow fiber membrane-containing filters including a filter housing having a first portion and a second portion and including a first end and a second end, the method comprising laying a plurality of the hollow fibers in the first portion of the filter housing to form a bundle of the hollow fibers, forming the first and second portions of the filter housing into the filter housing, sealing the first and second portions of the filter housing together, connecting the plurality of hollow fibers together at at least one of the first and second ends of the filter housing, connecting the plurality of hollow fibers to the filter housing and simultaneously adhering the first and second portions of the filter housing together by applying a potting compound thereto, and cutting the ends of the hollow fibers at the at least one of the first and second ends whereby the plurality of hollow fibers include open ends. In a preferred embodiment, the method includes sealing terminal end portions

to the first and second ends of the filter housing so as to cover the ends of the hollow fiber bundle.

[0020] In accordance with one embodiment of the method of the present invention, the laying of the plurality of the hollow fibers in the first portion of the filter housing comprises mounting a plurality of the first portions of the filter housing on a rotary winding wheel, continuously feeding the hollow fibers to the plurality of first portions of the filter housing as the rotary winding wheel is rotated, whereby the hollow fibers are laid serially in the plurality of first portions of the filter housings, and severing the hollow fibers between the plurality of filter housings. In a preferred embodiment, the method includes severing the hollow fibers between the plurality of filter housings after the sealing of the first and second portions of the filter housing together.

[0021] In accordance with one embodiment of the method of the present invention, the first and second portions of the filter housing are flexibly connected to each other, and the sealing of the first and second portions of the filter housing together includes swinging the first and second portions together. In a preferred embodiment, the first and second portions of the filter housing are flexibly connected to each other by means of a film hinge.

[0022] In accordance with another embodiment of the method of the present invention, the first and second portions of the filter housing are each half shell shaped, whereby the filter housing is tubular.

[0023] In accordance with another embodiment of the method of the present invention, the sealing of the terminal end portions to the first and second ends of the filter housing comprises a sealing method such as gluing, welding or screwing.

[0024] In accordance with another embodiment of the method of the present invention, the method includes clamping the first and second portions of the filter housing together prior

to sealing of the first and second portions of the filter housing together.

[0025] In accordance with the present invention, a hollow filter membrane-containing filter is provided comprising a tubular filter having a first portion and a second portion and including a first end and a second end, a bundle of hollow fibers disposed substantially parallel to each other within the filter housing, the first and second portions of the filter housing comprising half shell shapes, and potting compound connecting together the bundle of the hollow fibers at the first end of the tubular filter housing, connecting the bundle of hollow fibers to the tubular filter housing, and connecting the first and second portions of the tubular filter housing together. In a preferred embodiment, the hollow filter membrane includes a flexible connector connecting the first and second portions of the tubular filter housing together. In one embodiment the flexible connector comprises a film hinge.

[0026] In accordance with one embodiment of the hollow fiber membrane containing filter, the filter includes clamping members for connecting the first and second portions of the tubular filter housing together.

[0027] These—The objects of the present invention are achieved by way—means of a method wherein hollow fibrefibers are laid one after the other in a first housing portion to form a bundle, subsequently a second housing portion is placed on the first housing portion to form a filter housing, the housing portions are joined in a sealed fashion, the hollow fibrefibers are joined in a sealed fashion both to each other and to the filter housing at least at one end by means of a potting compound, and the potted fibrefiber ends are cut so that the hollow fibrefibers terminate with open ends, whereby the first housing portion and the second housing portion are adhered together by means of the potting compound when the hollow fibrefiber ends are potted.

[0028] This obviates an additional processing step for providing a sealed joint between both housing portions, so that the method as a whole becomes simple and less expensive. Polyurethane can be used as a potting compound, for example. This is particularly ~~favourable~~ favorable when polycarbonate or ABS (Acrylnitril-Butadiene-Styrol copolymer) is used as the material for the housing portions.

[0029] The advantageous method for adhering the two housing portions by means of the potting compound can also be reliably employed when the hollow fibrefibers are to be connected in a sealed fashion to one another and to the housing portions or the filter housing only at one end. In this case, for example, the potting compound can be fed in a suitable manner to the contact surfaces of the housing portions and to the ends of the hollow fibrefibers that are to be potted.

[0030] According to a preferred further embodiment, the hollow fibrefiber bundle ends are each covered with a terminating part that is connected to the filter housing in a sealed fashion.

[0031] With this method it is possible to manufacture filters of any desired size simply and reliably, while at the same time, the danger of contamination is significantly reduced ~~according to the preferred embodiment~~. The hollow fibrefibers are laid one after the other in the filter housing to form a bundle, and the filter housing is closed directly after completing the fibrefiber bundle. The fibrefiber bundle is thus exposed to the surrounding atmosphere for only a short time, so that the risk of contamination of the fibrefiber bundle is reduced. Also the risk of contamination of individual hollow fibrefibers during the formation of the fibrefiber bundle is reduced, as they are laid directly in the filter housing, and is not required to pass through several processing stages before arriving in the filter housing.

[0032] Laying the hollow fibrefibers one after another in the filter housing has the further advantage that filters of any desired size can be produced easily and without replacing

tools. Depending on the filter size, and thus the required size of the fibrefiber bundle, only the required number of hollow fibrefibers need be placed in the corresponding filter housing and the latter subsequently closed. In this—way manner, filters of any desired size, i.e. with any desired membrane surface, can be fabricated easily and with little outlay. In particular, it is no longer necessary to provide different tools for each of the different fibrefiber bundle sizes.

[0033] The method according to the present invention is further simplified when, in accordance with a particularly preferred embodiment, the hollow fibrefibers are fed continuously to a rotary winding wheel, on the outer circumference of which first housing portions are arranged. The housing portions are arranged such that the hollow fibrefibers can be laid in these first housing portions as the wheel rotates, while after placing the second housing portions on the first housing portions the hollow fibrefibers are severed between the filter housings.

[0034] In this—way manner, the ~~said~~ filters can be produced in a particularly simple fashion. The hollow fibrefibers are continually wound into the housing portions arranged on the outer circumference of the winding wheel until the desired fibrefiber bundle thickness, and therefore the desired membrane surface is obtained. It is advantageous that several filters or fibrefiber bundles can be made simultaneously in one process step, namely the winding of the hollow fibrefibers on the winding wheel. The number of generated filters or fibrefiber bundles depends, *inter alia*, on the diameter of the winding wheel. A winding wheel with a large diameter has a larger outer circumference on which more housing portions can be arranged one behind the other. Likewise, the width of the winding wheel determines the number of filters of fibrefiber bundles that can be made in one processing stage. If the winding wheel is wide enough, two or more housing portions can be laid side by side, so that two or more rows of housing

portions arranged one after another into which the hollow fibrefibers can be wound are provided on the outer circumference. This all contributes to providing a simple and inexpensive method.

[0035] It is furthermore advantageous when, in accordance with another embodiment, the second housing portion is flexibly joined to the first housing portion so that it need only be swung onto the first housing portion. For example, the first and second housing portions could be flexibly joined by means of a film hinge. This simplifies and facilitates the manufacture of the filter housing itself, since the first and second housing portions can be formed together as one part.

[0036] A further improvement of the method of the present invention is obtained when both housing portions are formed half-shell-shaped, and the second half-shell-shaped housing portion is placed on the first half-shell-shaped housing portion to form a tubular filter housing, ~~in accordance with a further preferred embodiment~~. This facilitates on the one hand the winding of the hollow fibrefibers in the first housing portion, as the half-shell shape of the first housing portion causes the hollow fibrefibers to be centered as they are wound. On the other hand, the fibrefiber bundle with the hollow fibrefibers arranged essentially in parallel is surrounded in a manner adapted to its contours by the finished tubular filter housing. Thus, no superfluous space is present around the fibrefiber bundle that could accommodate unnecessarily large amounts of dialysis fluid, for example. Furthermore, the fibrefiber bundle is supported from the outside so that the individual hollow fibrefibers are securely held in the bundle. Mechanical damage to the hollow fibrefibers is consequently avoided.

[0037] The terminating parts covering the hollow fibrefiber ends can be connected to the filter housing in any desired manner, provided that a sealed and reliable joint is obtained. However, it is advantageous when the terminating parts are glued or welded or are screwed on to the filter housing. In

this—way manner, a simple, secure and reliable connection between terminating parts and filter housing is obtained.

[0038] The objects of the present invention are thus is achieved by way—means of an apparatus, wherein the tubular filter housing is composed of two half-shells, and wherein the two half-shells are adhered together by means of the potting compound.

[0039] In this way—manner, the filters can be made simply and inexpensively without excessive outlay, as the hollow ~~fibrefibers~~ can be laid one after the other in a first half-shell. Depending on the desired filter size or ~~fibrefiber~~ bundle size that determines the membrane surface, the required number of hollow ~~fibrefibers~~ can be laid in the filter housing. The thus formed ~~fibrefiber~~ bundle can then be covered directly by the second half-shell, that is placed on the first half-shell, so that, on the one hand, damage to the hollow ~~fibrefibers~~, or the ~~fibrefiber~~ bundle, by external forces is avoided, and on the other hand, the risk of contamination is reduced.

[0040] In accordance with a preferred embodiment, it is advantageously provided that the tubular filter housing is composed of two flexibly connected half-shells, the two half-shells being especially—preferably flexibly connected by means of a film hinge. In this way—manner, the manufacture of the filter housing per se is inter alia simplified, because the first and second half-shells are formed as one piece and can be fabricated together. After laying the hollow ~~fibrefibers~~ in the first half-shell, the second half-shell need only be swung onto the first half-shell to form the tubular housing for the filter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0041] Further features and advantages of the present invention will be described in more detail with reference to preferred—embodiments and—the following detailed description, which, in turn, refers to the enclosed drawings, wherein:- These show in

[0042] Fig. 1 is a side, elevational, schematic side-view of a winding wheel used in the method of the present invention;

[0043] Fig. 2 is a side, perspective view of an open filter housing;

[0044] Fig. 3 is a top, plane view of an open filter housing with a partially shown ~~fibrefiber~~ bundle;

[0045] Fig. 4 is a front, elevational, sectional view through the filter housing of Fig. 3 taken along the line A-A thereof;

[0046] Fig. 5 is a side, perspective view of a filter housing connected in a sealed fashion by means of ultrasound welding, with terminating parts;

[0047] Fig. 6 is a top, plan view of an open filter housing for connecting both housing portions in a sealed fashion by means of the potting compound; and

[0048] Fig. 7 is a side perspective view of a filter housing with terminating parts joined in a sealed manner by means of the potting compound of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0049] Referring to the drawings, Fig. 1 shows a side view of a winding wheel 9. On the outer circumference of the winding wheel 9 several filter housings 13 are arranged in such a way that hollow ~~fibrefibers~~ 1 can be wound in the filter housing 13. The hollow ~~fibrefibers~~ 1 are fed from a supply roller 3 to a distributor apparatus 5, and from there further to the winding wheel 9. It is to be noted at this point that the hollow ~~fibrefibers~~ could also be supplied to the distributor apparatus directly from a production machine, or spinning machine.

[0050] Several distributor rollers 7 are arranged on the distributor apparatus 5 and each feeds individual hollow ~~fibrefibers~~ 1 to the filter housings 13 arranged on the winding wheel 9. The distributor rollers 7 are movable in their longitudinal axes and are controlled such that the individual hollow ~~fibrefibers~~ 1 are placed in the filter

housings 13 offset relative to one another and distributed across the whole housing width. The hollow fibrefibers 1 are unwound from the supply roller 3 and wound on the winding wheel 9, or rather in the filter housings 13 arranged on the outer circumference of the winding wheel, as the winding wheel 9 is turned as indicated by the arrow 11. A tension roller 15 is disposed between the supply roller 3 and the distributor apparatus 5 and holds the hollow fibrefibers 1 under a certain tension to enable the controlled deposit or winding of the hollow fibrefibers 1 in the filter housings 13 on the winding wheel. The tension can be applied to the tension roller 15, or the hollow fibrefibers 1, as indicated by the arrow at 15 using spring force or weight.

[0051] The individual distributor rollers 7 can also each feed two or more hollow fibrefibers 1 to the filter housings 13 disposed on the winding wheel 9. In this case, the hollow fibrefibers 1 supplied to the filter housings 13 by the different distributor rollers 7 are placed in the filter housings 13 displaced in groups relative to one another.

[0052] Fig. 2 shows a perspective view of an open filter housing 13. The filter housing 13 consists of a first half-shell-shaped housing portion 21 and a second half-shell-shaped housing portion 23, that are flexibly connected with one another by means of a film hinge 27. The first housing portion 21 comprises a connection 25 and a weld or adhesion strip 33 on the longitudinal side opposing the film hinge 27. The second housing portion 23 likewise comprises a weld or adhesion strip 35 on the longitudinal side opposing the film hinge 27. Several clamp stubs 29 are disposed on the weld or adhesion strip 33 of the first housing portion 21 and are constructed such that they can engage with correspondingly constructed apertures 31 on the weld or adhesion strip 35 of the second housing portion 23. To close the filter housing 13, the second housing portion 23 is pivoted onto the first housing portion 21 by means of the film hinge 27, so that the clamp stubs 29 latch into the apertures 31 and affix the first

and second housing portions, 21, and 23, together, with the weld and adhesion strips, 33 and 35, lying on top of one another. These are then joined in a sealed fashion by welding or gluing, as will be described later in more detail.

[0053] However, the sealed connection of the two housing portions 21 and 23 occurs only when the desired number of hollow fibrefibers 1 has been laid in the first housing portion 21 and forms the desired bundle. To permit this, the filter housing 13 is disposed on the outer circumference of the winding wheel 9 (Fig. 1) in the open state shown in Fig. 2 in such a manner that at least the inside of the first housing portion 21 is directed outwardly. In this way, the hollow fibrefibers 1 can be wound into the filter housing 13 as described with reference to Fig. 1.

[0054] Fig. 3 shows a plan view of a filter housing 13, wherein a hollow fibrefiber bundle 41 arranged in the first housing portion 21 is partially depicted. The filter housing 13 corresponds essentially to the filter housing 13 shown in Fig. 2 and described with reference to Fig. 2, so a renewed detail description can be dispensed with. In contrast to the filter housing 13 shown in Fig. 2, the clamp stubs 43 are not arranged on the weld or adhesion strip 33, but rather on the outer edge of ~~the~~ same. Also, the apertures 45 are not arranged in the weld or adhesion strip 35 of the second housing portion 23, but likewise on the outer edge of ~~the~~ same.

[0055] It should be noted at this stage that the connector 25 arranged on the first housing portion 21 need not necessarily be disposed there. For example, the connector 25 could also be arranged on the terminating part that is described below in detail. Likewise, the connector 25 could be arranged on the second housing portion 23, or two or more connectors 25 could be provided, which may be arranged on the first or second housing portions, 21, and 23, or on the terminating parts still to be described, as desired.

[0056] As can be seen well in Fig. 3, the hollow fibrefiber bundle 41 lies with hollow fibrefibers 1 arranged essentially in parallel in the half-shell-shaped first housing portion 21 and fills the latter substantially completely. This can also be seen well from Fig. 4, which shows a section through the filter housing 13 along the line A-A in Fig. 3. The hollow fibrefiber bundle 41 fills the cross section essentially fully, so that when the filter housing 13 is closed, that is, when the second housing portion 23 has been swung onto the first housing portion 21, it is supported mechanically by the filter housing 13. However it is not compressed by the filter housing 13; the hollow fibrefibers are still separated from one another by a certain space or play.

[0057] Fig. 5 shows a perspective view of a filter housing 13 in the closed state with mounted terminating parts 47. The terminating parts 47 that are placed, respectively, on the ends of the tubular filter housing each comprise a further connector 49. As for the connectors 25, the connectors 49 can be of any desired structure and, for example, can comprise a screw thread for connecting a conduit. The terminating parts 47 themselves can be placed on the filter housing in any desired manner, for example, they can be screwed on or be connected in a sealed fashion to the filter housing by welding or adhesion. In the embodiment illustrated ~~here~~, the first housing portion 21 and the second housing portion 23 of the filter housing 13 ~~shown here~~ are connected together in a sealed manner by ultrasonic welding of the weld strip 33 on the first housing portion 21 to the weld strip 35 on the second housing portion 23.

[0058] This is only one possibility for connecting the first and second housing portions, 21, and 23, in a sealed fashion. Another possibility that was mentioned above, is the gluing together of the first and second housing portions, 21, and 23, by means of the potting compound when potting the hollow fibrefibers. A plan view of a correspondingly formed filter housing 13 is shown in Fig. 6.

[0059] To simplify the description, like parts are provided with like reference numerals. In contrast to the above described filter housings 13, the first and second housing portions, 21 and 23, each comprise a potting strip 51 on their longitudinal sides opposing the film hinge 27. In their central areas, the potting strips 51 each have a potting aperture 53 and, at their ends, an outlet aperture 57. A potting channel 55 extends from the potting aperture 53 on both sides towards the outlet apertures 57. Clamping means 59 are arranged in the potting strip 51 on the first housing portion 21 and are formed such that they engage with corresponding clamping means 61 arranged in the potting strip 51 of the second housing portion 23. These clamping means, 59 and 61, engage in one another and hold the filter housing 13 in a closed position when the second housing portion 23 is swung onto the first housing 21 by means of the film hinge 27.

[0060] In this closed state shown in Fig. 7, the potting strips 51 of the first and second housing portions, 21 and 23, lie against one another so that the potting channel 55 is closed. If a potting compound, for example polyurethane, is now poured into the potting aperture 53, it will flow through the potting channel 55 towards the outlet apertures 57 and will exit there through these outlet apertures 57 into the interior of the filter housing 13, to pot the hollow ~~fibrefiber~~ ends. The flow movement of the potting compound towards the outlet apertures 57 and thus the potting of the hollow ~~fibrefiber~~ ends can, for example, be effectively assisted when the filter housing 13 is rotated to generate centrifugal forces acting in the direction of the ends of the filter housing 13.

[0061] After hardening, the potting compound remaining in the potting channel 55 sticks together the connected housing portions, 21 and 23, that are affixed by means of the clamping means, 59 and 61, and seals the joint at the same time. A filter housing 13 made in this way is shown in perspective view in Fig. 7. Here again, like parts are

provided with like reference numerals to simplify the description. Here the combined potting strips 51 with the potting aperture 53 in the centre are easily identifiable.

[0062] Although the invention herein has been described with reference to particular embodiments, it is to be understood that these embodiments are merely illustrative of the principles and applications of the present invention. It is therefore to be understood that numerous modifications may be made to the illustrative embodiments and that other arrangements may be devised without departing from the spirit and scope of the present invention as defined by the appended claims.

317006_1 DOC

FILTERS AND METHOD FOR PRODUCING FILTERS

The present invention concerns a method for producing filters with membranes of hollow fibres, for example for dialysis. It further relates to a filter with membranes of hollow fibres, in which the hollow fibres are arranged
5 as a bundle essentially parallel to one another in a tubular filter housing.

TECHNICAL BACKGROUND

Filters with membranes of hollow fibres are employed for the most diverse purposes in the field of dialysis. For example, such filters are utilised
10 for haemodialysis, in which blood is passed through the inside of hollow fibres constructed with semi-permeable walls and dialysis fluid is caused to flow past the outside of the hollow fibres. During this, diverse convection and diffusion processes take place across the walls of the hollow fibres that result in a cleansing of the blood and removal of superfluous fluid. Furthermore, the
15 electrolyte concentration in the blood is conditioned and buffers such as bicarbonate or acetate, for example, are added to the blood.

Filters of this kind are also utilised for so-called haemofiltration, in which a substitution fluid is added to the blood. The blood is fed through the hollow fibres, but no dialysis fluid flows past the outer surface of the hollow
20 fibres. In this case, superfluous fluid, in particular water, is removed from the blood solely with the aid of a pressure difference across the membrane, i.e. the semi-permeable wall of the hollow fibres. The substitution fluid can be added to the blood either before the filter or after the filter.

The above-mentioned filters can also be used for producing the
25 substitution fluid itself; they are then called ultrafilters. In this case, water is fed through the hollow fibres and, by means of a pressure difference across the membrane or semi-permeable walls, filtered through the same; the water is filtered sterile by the removal of bacteria and endotoxins as well as other contamination products.

30 Further utilisations of the above-mentioned filters are for example

haemodiafiltration, a combination of haemodialysis and haemofiltration, and plasmapheresis, in which the aqueous blood plasma is filtered out of the blood and fed back into the blood after treatment. However such filters are also used for reverse osmosis.

- 5 Several processes are known for making filters with membranes. For example, a process is known from DE-C-28 24 898, in which several hollow fibre lengths are continuously combined to form a bundle. This bundle is then fed step-wise to a potting apparatus that pots a limited area of the fibre bundle with a potting compound so that a firm block is created that encloses the
- 10 hollow fibres. In this way, by the step-wise advancing of the fibre bundle, firm areas or blocks are formed on the fibre length at predetermined distances. In the subsequent process, the fibre length is divided into individual bundles by severing each of the firm blocks through the middle. In this way individual bundles with firm end regions are created. These firm end regions are
- 15 processed in a further step such that the fibre bundle enclosed in the firm region terminates with open ends. The thus formed fibre bundle is then put into a two-part housing. Subsequently, the two housing parts are brought together and firmly joined.

- 20 A disadvantage of this known process is inter alia the many process steps, which are expensive in terms of apparatus and cost. Furthermore, with this known process only bundles of one size for filters, or filter housings of one size, can be produced. To produce fibre bundles with different sizes for filters of different sizes the potting device must be replaced. This determines the size of the fibre bundle.

- 25 Furthermore, with this known process there is a high danger of contamination for the hollow fibres and the finished fibre bundle, as numerous processing steps are necessary and consequently much time passes before the hollow fibres or the fibre bundle is enclosed in the housing and sealed from the environment.

This is true for the filters manufactured with this process as well as for other filters, for which a fibre bundle is fabricated in several processing steps and subsequently combined with other parts to form a filter. Examples for such filters are disclosed in DE-A-28 44 941, DE-A-28 45 002 and DE-A-28 45 003. The filters disclosed therein are each composed of several frames holding fibre bundles. The individual frames with finished fibre bundles are set on top of one another and clamped together by means of clamps, which form the housing. By adding end portions that include connections for inlet and outlet, the filter is finally completed.

Another known process consists of the feeding of hollow fibres to a winding wheel and winding these in sleeve lower parts arranged on the outer circumference thereof by turning the wheel. As soon as the desired fibre bundle thickness or fibre bundle size has been reached, the winding wheel is stopped and the sleeve upper parts are placed on the sleeve lower parts and fixed there. Subsequently, the hollow fibres are cut between the sleeves, the sleeves are removed from the winding wheel and transferred to an apparatus for taking the finished fibre bundles out of the sleeves and placing them into tubular filter casings.

This known process also has the disadvantage of numerous processing steps, so that in addition to the high constructional expense and the attendant cost there also exists a high danger of contamination of the finished fibre bundle, as has been described in detail above.

From US 4 341 005 a process is known where hollow fibers are fed to a winding wheel and are wound in first housing portions of a filter placed on the periphery of the winding wheel. If the first housing portions are full or slightly overfull, a second housing portion is placed over each fiber filled first housing portion. The two housing portions are secured together, and the hollow fibers between the housings are then cut. The housings are removed from the winding wheel, and the hollow fibers at the ends of the housings are thereafter potted by centrifugal castings which also permits the potting compound to join

3a

with or to adhere to the housing walls as well as to the hollow fibers.

Following this potting the ends of the hollow fibers are again cut in the area of the potting compound to reexpose the hollow core and end caps are sealed onto the housings to complete the filter.

5 Even if with this known process the risk for contamination of the finished fiber bundle is reduced, this known process still has the disadvantage of numerous processing steps.

From US 4 343 668 a more complex process is known, where a potting compound is applied at spaced intervals on the hollow fibers during rotation of the winding wheel. This requires a complex and complicated device leading to high constructional expenses and attendant costs.

From US 4 038 190 a process is known where hollow fibers are wound on a core, whereafter the core is placed in a housing.

15 This known process also has the disadvantage of numerous processing steps, so that in addition to the high constructional expenses and the attendant costs there is also a high risk for contamination of the finished fiber bundle as has been described in detail above.

DESCRIPTION OF THE INVENTION

20 In view of this background it is thus the object of the present invention to provide a method for producing filters with membranes of hollow fibres, for example for dialysis, whereby filters of any desired size can inexpensively and easily be reliably manufactured without excessive outlay, and with which the danger of contamination of the fibre bundle during fabrication of the filter is
25 reduced.

A further object of the present invention is to provide a filter with membranes of hollow fibres, in which the hollow fibres are arranged essentially parallel to one another as a bundle in a tubular filter housing and that can be easily, inexpensively and reliably fabricated without excessive outlay.

These objects are achieved by way of a method wherein hollow fibres are laid one after the other in a first housing portion to form a bundle, subsequently a second housing portion is placed on the first housing portion to form a filter housing, the housing portions are joined in a sealed fashion, the hollow fibres are joined in a sealed fashion both to each other and to the filter housing at least at one end by means of a potting compound, and the potted fibre ends are cut so that the hollow fibres terminate with open ends, whereby the first housing portion and the second housing portion are adhered together by means of the potting compound when the hollow fibre ends are potted.

This obviates an additional processing step for providing a sealed joint between both housing portions, so that the method as a whole becomes simple and less expensive. Polyurethane can be used as a potting compound, for example. This is particularly favourable when polycarbonate or ABS (Acrylnitril-Butadiene-Styrol copolymer) is used as the material for the housing portions.

The advantageous method for adhering the two housing portions by means of the potting compound can also be reliably employed when the hollow fibres are to be connected in a sealed fashion to one another and to the housing portions or the filter housing only at one end. In this case, for example, the potting compound can be fed in a suitable manner to the contact surfaces of the housing portions and to the ends of the hollow fibres that are to be potted.

According to a preferred further embodiment, the hollow fibre bundle ends are each covered with a terminating part that is connected to the filter housing in a sealed fashion.

With this method it is possible to manufacture filters of any desired size simply and reliably, while at the same time, the danger of contamination is significantly reduced according to the preferred embodiment. The hollow fibres are laid one after the other in the filter housing to form a bundle, and the
5 filter housing is closed directly after completing the fibre bundle. The fibre bundle is thus exposed to the surrounding atmosphere for only a short time, so that the risk of contamination of the fibre bundle is reduced. Also the risk of contamination of individual hollow fibres during the formation of the fibre bundle is reduced, as they are laid directly in the filter housing, and is not
10 required to pass through several processing stages before arriving in the filter housing.

Laying the hollow fibres one after another in the filter housing has the further advantage that filters of any desired size can be produced easily and without replacing tools. Depending on the filter size, and thus the required
15 size of the fibre bundle, only the required number of hollow fibres need be placed in the corresponding filter housing and the latter subsequently closed. In this way, filters of any desired size, i.e. with any desired membrane surface, can be fabricated easily and with little outlay. In particular, it is no longer necessary to provide different tools for each of the different fibre bundle sizes.

20 The method according to the invention is further simplified when, in accordance with a particularly preferred embodiment, the hollow fibres are fed continuously to a rotary winding wheel, on the outer circumference of which first housing portions are arranged. The housing portions are arranged such that the hollow fibres can be laid in these first housing portions as the wheel
25 rotates, while after placing the second housing portions on the first housing portions the hollow fibres are severed between the filter housings.

In this way, the said filters can be produced in a particularly simple fashion. The hollow fibres are continually wound into the housing portions arranged on the outer circumference of the winding wheel until the desired
30 fibre bundle thickness, and therefore the desired membrane surface is

obtained. It is advantageous that several filters or fibre bundles can be made simultaneously in one process step, namely the winding of the hollow fibres on the winding wheel. The number of generated filters or fibre bundles depends inter alia on the diameter of the winding wheel. A winding wheel with a large
5 diameter has a larger outer circumference on which more housing portions can be arranged one behind the other. Likewise, the width of the winding wheel determines the number of filters or fibre bundles that can be made in one processing stage. If the winding wheel is wide enough, two or more housing portions can be laid side by side, so that two or more rows of housing portions
10 arranged one after another into which the hollow fibres can be wound are provided on the outer circumference. This all contributes to providing a simple and inexpensive method.

It is furthermore advantageous when, in accordance with another embodiment, the second housing portion is flexibly joined to the first housing
15 portion so that it need only be swung onto the first housing portion. For example, the first and second housing portions could be flexibly joined by means of a film hinge. This simplifies and facilitates the manufacture of the filter housing itself, since the first and second housing portions can be formed together as one part.

20 A further improvement of the method is obtained when both housing portions are formed half-shell-shaped, and the second half-shell-shaped housing portion is placed on the first half-shell-shaped housing portion to form a tubular filter housing, in accordance with a further preferred embodiment. This facilitates on the one hand the winding of the hollow fibres in the first
25 housing portion, as the half-shell shape of the first housing portion causes the hollow fibres to be centred as they are wound. On the other hand, the fibre bundle with the hollow fibres arranged essentially in parallel is surrounded in a manner adapted to its contours by the finished tubular filter housing. Thus no superfluous space is present around the fibre bundle that could accommodate
30 unnecessarily large amounts of dialysis fluid, for example. Furthermore, the

fibre bundle is supported from the outside so that the individual hollow fibres are securely held in the bundle. Mechanical damage to the hollow fibres is consequently avoided.

The terminating parts covering the hollow fibre ends can be connected
5 to the filter housing in any desired manner, provided that a sealed and reliable joint is obtained. However, it is advantageous when the terminating parts are glued or welded or are screwed on to the filter housing. In this way, a simple, secure and reliable connection between terminating parts and filter housing is obtained.

10 The object is achieved by way of an apparatus, wherein the tubular filter housing is composed of two half-shells, and wherein the two half-shells are adhered together by means of the potting compound.

In this way the filters can be made simply and inexpensively without excessive outlay, as the hollow fibres can be laid one after the other in a first
15 half-shell. Depending on the desired filter size or fibre bundle size that determines the membrane surface, the required number of hollow fibres can be laid in the filter housing. The thus formed fibre bundle can then be covered directly by the second half-shell, that is placed on the first half-shell, so that, on the one hand, damage to the hollow fibres, or the fibre bundle, by external
20 forces is avoided, and on the other hand, the risk of contamination is reduced.

In accordance with a preferred embodiment, it is advantageously provided that the tubular filter housing is composed of two flexibly connected

half-shells, the two half-shells being especially preferably flexibly connected by means of a film hinge. In this way the manufacture of the filter housing per se is inter alia simplified, because the first and second half-shells are formed as one piece and can be fabricated together. After laying the hollow fibres in the first half-shell, the second half-shell need only be swung onto the first half-shell to form the tubular housing for the filter.

DESCRIPTION OF THE DRAWINGS

Further features and advantages of the invention will be described in more detail with reference to preferred embodiments and the enclosed drawings. These show in

Fig. 1 a schematic side view of a winding wheel;

Fig. 2 a perspective view of an open filter housing;

Fig. 3 a plane view of an open filter housing with a partially shown fibre bundle;

Fig. 4 a sectional view through the filter housing of Fig. 3 along the line A-A;

Fig. 5 a perspective view of a filter housing connected in a sealed fashion by means of ultrasound welding, with terminating parts;

Fig. 6 a plan view of an open filter housing for connecting both housing portions in a sealed fashion by means of the potting compound; and

Fig. 7 a perspective view of a filter housing with terminating parts joined in a sealed manner by means of the potting compound.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 shows a side view of a winding wheel 9. On the outer circumference of the winding wheel 9 several filter housings 13 are arranged in such a way that hollow fibres 1 can be wound in the filter housing 13. The hollow fibres 1 are fed from a supply roller 3 to a distributor apparatus 5, and from there further to the winding wheel 9. It is to be noted at this point that the

hollow fibres could also be supplied to the distributor apparatus directly from a production machine, or spinning machine.

Several distributor rollers 7 are arranged on the distributor apparatus 5 and each feeds individual hollow fibres 1 to the filter housings 13 arranged on the winding wheel 9. The distributor rollers 7 are movable in their longitudinal axes and are controlled such that the individual hollow fibres 1 are placed in the filter housings 13 offset relative to one another and distributed across the whole housing width. The hollow fibres 1 are unwound from the supply roller 3 and wound on the winding wheel 9, or rather in the filter housings 13 arranged on the outer circumference of the winding wheel, as the winding wheel 9 is turned as indicated by the arrow 11. A tension roller 15 is disposed between the supply roller 3 and the distributor apparatus 5 and holds the hollow fibres 1 under a certain tension to enable the controlled deposit or winding of the hollow fibres 1 in the filter housings 13 on the winding wheel. The tension can be applied to the tension roller 15, or the hollow fibres 1, as indicated by the arrow at 15 using spring force or weight.

The individual distributor rollers 7 can also each feed two or more hollow fibres 1 to the filter housings 13 disposed on the winding wheel 9. In this case, the hollow fibres 1 supplied to the filter housings 13 by the different distributor rollers 7 are placed in the filter housings 13 displaced in groups relative to one another.

Fig. 2 shows a perspective view of an open filter housing 13. The filter housing 13 consists of a first half-shell-shaped housing portion 21 and a second half-shell-shaped housing portion 23, that are flexibly connected with one another by means of a film hinge 27. The first housing portion 21 comprises a connection 25 and a weld or adhesion strip 33 on the longitudinal side opposing the film hinge 27. The second housing portion 23 likewise comprises a weld or adhesion strip 35 on the longitudinal side opposing the film hinge 27. Several clamp stubs 29 are disposed on the weld or adhesion strip 33 of the first housing portion 21 and are constructed such that they can

engage with correspondingly constructed apertures 31 on the weld or adhesion strip 35 of the second housing portion 23. To close the filter housing 13, the second housing portion 23 is pivoted onto the first housing portion 21 by means of the film hinge 27, so that the clamp stubs 29 latch into the apertures 31 and affix the first and second housing portions 21, 23 together, with the weld and adhesion strips 33 and 35 lying on top of one another. These are then joined in a sealed fashion by welding or gluing, as will be described later in more detail.

However, the sealed connection of the two housing portions 21 and 23 occurs only when the desired number of hollow fibres 1 has been laid in the first housing portion 21 and forms the desired bundle. To permit this, the filter housing 13 is disposed on the outer circumference of the winding wheel 9 (Fig. 1) in the open state shown in Fig. 2 in such a manner that at least the inside of the first housing portion 21 is directed outwardly. In this way, the hollow fibres 1 can be wound into the filter housing 13 as described with reference to Fig. 1.

Fig. 3 shows a plan view of a filter housing 13, wherein a hollow fibre bundle 41 arranged in the first housing portion 21 is partially depicted. The filter housing 13 corresponds essentially to the filter housing 13 shown in Fig. 2 and described with reference to Fig. 2, so a renewed detail description can be dispensed with. In contrast to the filter housing 13 shown in Fig. 2, the clamp stubs 43 are not arranged on the weld or adhesion strip 33, but rather on the outer edge of the same. Also the apertures 45 are not arranged in the weld or adhesion strip 35 of the second housing portion 23, but likewise on the outer edge of the same.

It should be noted at this stage that the connector 25 arranged on the first housing portion 21 need not necessarily be disposed there. For example, the connector 25 could also be arranged on the terminating part that is described below in detail. Likewise, the connector 25 could be arranged on the second housing portion 23, or two or more connectors 25 could be provided,

which may be arranged on the first or second housing portions 21, 23 or on the terminating parts still to be described, as desired.

As can be seen well in Fig. 3, the hollow fibre bundle 41 lies with hollow fibres 1 arranged essentially in parallel in the half-shell-shaped first housing portion 21 and fills the latter substantially completely. This can also be seen well from Fig. 4, which shows a section through the filter housing 13 along the line A-A in Fig. 3. The hollow fibre bundle 41 fills the cross section essentially fully, so that when the filter housing 13 is closed, that is, when the second housing portion 23 has been swung onto the first housing portion 21, it is supported mechanically by the filter housing 13. However it is not compressed by the filter housing 13; the hollow fibres are still separated from one another by a certain space or play.

Fig. 5 shows a perspective view of a filter housing 13 in the closed state with mounted terminating parts 47. The terminating parts 47 that are placed, respectively, on the ends of the tubular filter housing each comprise a further connector 49. As for the connectors 25, the connectors 49 can be of any desired structure and, for example, comprise a screw thread for connecting a conduit. The terminating parts 47 themselves can be placed on the filter housing in any desired manner, for example, they can be screwed on or be connected in a sealed fashion to the filter housing by welding or adhesion. In the embodiment illustrated here, the first housing portion 21 and the second housing portion 23 of the filter housing 13 shown here are connected together in a sealed manner by ultrasonic welding of the weld strip 33 on the first housing portion 21 to the weld strip 35 on the second housing portion 23.

This is only one possibility for connecting the first and second housing portions 21, 23 in a sealed fashion. Another possibility that was mentioned above, is the gluing together of the first and second housing portions 21, 23 by means of the potting compound when potting the hollow fibres. A plan view of a correspondingly formed filter housing 13 is shown in Fig. 6.

To simplify the description, like parts are provided with like reference numerals. In contrast to the above described filter housings 13, the first and second housing portions 21, 23 each comprise a potting strip 51 on their longitudinal sides opposing the film hinge 27. In their central areas, the potting strips 51 each have a potting aperture 53 and, at their ends, an outlet aperture 57. A potting channel 55 extends from the potting aperture 53 on both sides towards the outlet apertures 57. Clamping means 59 are arranged in the potting strip 51 on the first housing portion 21 and are formed such that they engage with corresponding clamping means 61 arranged in the potting strip 51 of the second housing portion 23. These clamping means 59, 61 engage in one another and hold the filter housing 13 in a closed position when the second housing portion 23 is swung onto the first housing 21 by means of the film hinge 27.

In this closed state shown in Fig. 7, the potting strips 51 of the first and second housing portions 21, 23 lie against one another so that the potting channel 55 is closed. If a potting compound, for example polyurethane, is now poured into the potting aperture 53, it will flow through the potting channel 55 towards the outlet apertures 57 and will exit there through these outlet apertures 57 into the interior of the filter housing 13, to pot the hollow fibre ends. The flow movement of the potting compound towards the outlet apertures 57 and thus the potting of the hollow fibre ends can, for example, be effectively assisted when the filter housing 13 is rotated to generate centrifugal forces acting in the direction of the ends of the filter housing 13.

After hardening, the potting compound remaining in the potting channel 55 sticks together the connected housing portions 21, 23 that are affixed by means of the clamping means 59 and 61 and seals the joint at the same time. A filter housing 13 made in this way is shown in perspective view in Fig. 7. Here again, like parts are provided with like reference numerals to simplify the description. Here the combined potting strips 51 with the potting aperture 53 in the centre are easily identifiable.

CLAIMS

1. Method for producing filters with membranes of hollow fibres, for example for dialysis, wherein

hollow fibres (1) are laid one after the other in a first housing portion
5 (21) to form a bundle,

subsequently, a second housing portion (23) is placed on the first housing portion (21) to form a filter housing (13),

the two housing portions (21, 23) are connected together in a sealed fashion,

10 at least at one end, the hollow fibres (1) are connected together and with the filter housing (13) in a sealed fashion by means of a potting compound,

and the potted hollow fibre ends are cut so that the hollow fibres (1) terminate with open ends,

characterised in that the first housing portion (21) and the second housing
15 portion (23) are adhered together by means of the potting compound when the hollow fibre ends are potted.

2. Method according to claim 1, **characterised in** that the hollow fibre bundle ends are each covered with a terminating part (47), which is
20 connected to the filter housing (13) in a sealed fashion.

3. Method according to claim 1 or 2, **characterised in** that hollow fibres (1) are continuously fed to a rotary winding wheel (9), on the outer circumference of which first housing portions (21) are arranged in such a
25 manner that the hollow fibres (1) are laid one after the other in the first housing portions (21) as the winding wheel (9) is rotated,

and that after placing the second housing portion (23) on the first housing portion (21), the hollow fibres (1) are severed between the filter housings (13).

4. Method according to one of the previous claims, characterised in that the second housing portion (23) is flexibly connected to the first housing portion (21) and is swung over onto the first housing portion (21).

5. Method according to claim 4, characterised in that the second housing portion (23) is flexibly connected to the first housing portion (21) by means of a film hinge (27), and is swung over onto the first housing portion (21).

10 6. Method according to one of the previous claims, characterised in that the second housing portion (23) is half-shell-shaped and is placed on the first housing portion (21) which is also half-shell-shaped to form a tubular filter housing (13).

15 7. Method according to one of the previous claims, characterised in that the terminating parts (47) are glued or welded to the filter housing (13) or are screwed onto the filter housing (13).

20 8. Method according to one of the previous claims, characterised in that the first and second housing portions (21, 23) are fastened together by means of clamping means (43, 45; 59, 61) arranged thereon before they are joined in a sealed fashion.

9. Filter with membranes of hollow fibres, for example for dialysis, wherein the hollow fibres are arranged as a bundle essentially parallel to one another in a tubular filter housing, and, at least at one end, are connected together and with the tubular filter housing in a sealed fashion by means of a potting compound, **characterised in** that the tubular filter housing (13) is composed of two half shells (21, 23), and in that the two half shells (21, 23) are adhered together by means of the potting compound.

10. Filter according to claim 9, **characterised in** that the tubular filter housing (13) is composed of two flexibly connected half shells (21, 23).

11. Filter according to claim 10, **characterised in** that the tubular filter housing (13) is composed of two half shells (21, 23) that are flexibly connected by means of a film hinge (27).

12. Filter according to one of claims 9 to 11, **characterised in** that the half shells (21, 23) comprise clamping means (43, 45; 59, 61), whereby the half shells (21, 23) are connectable to one another.

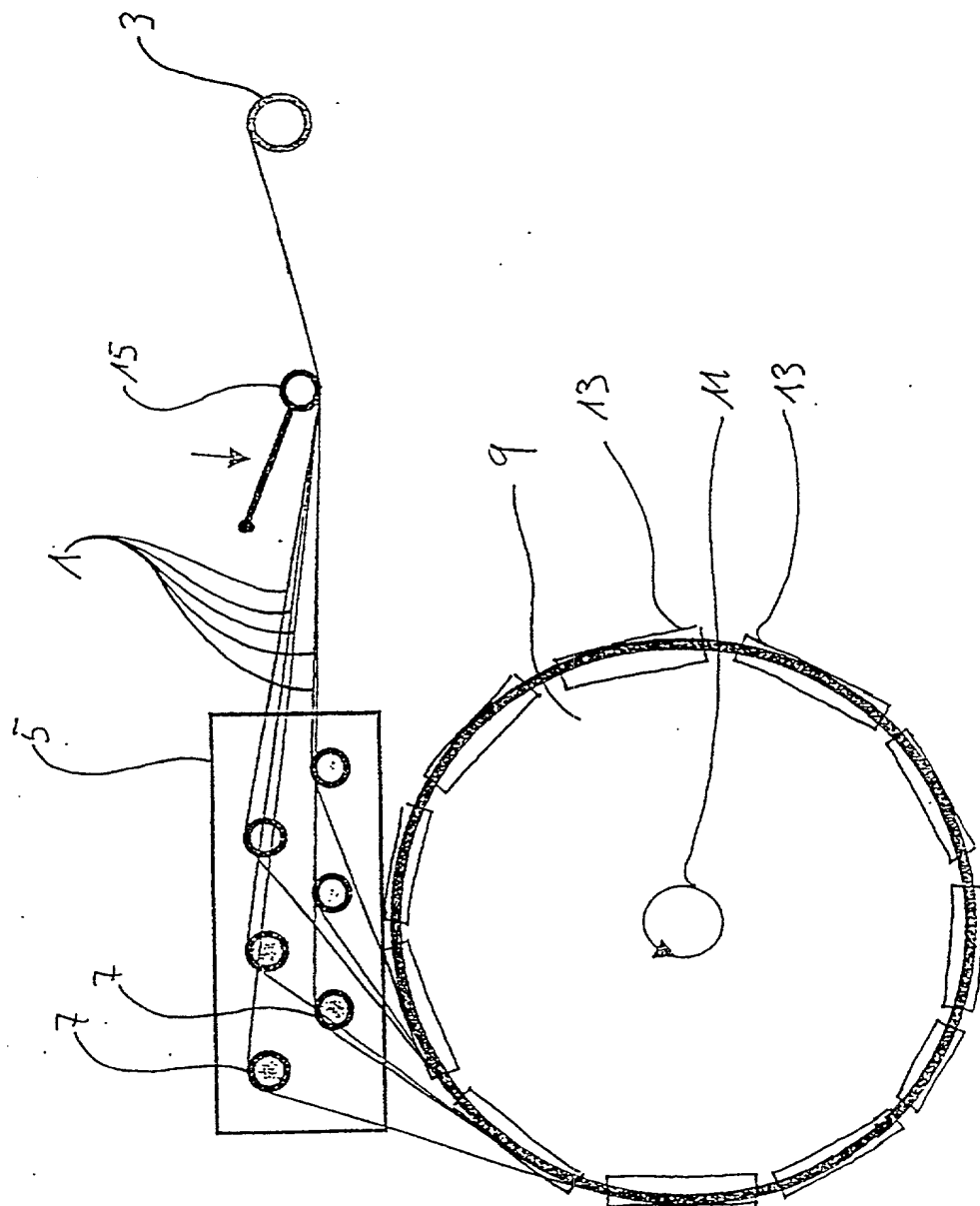
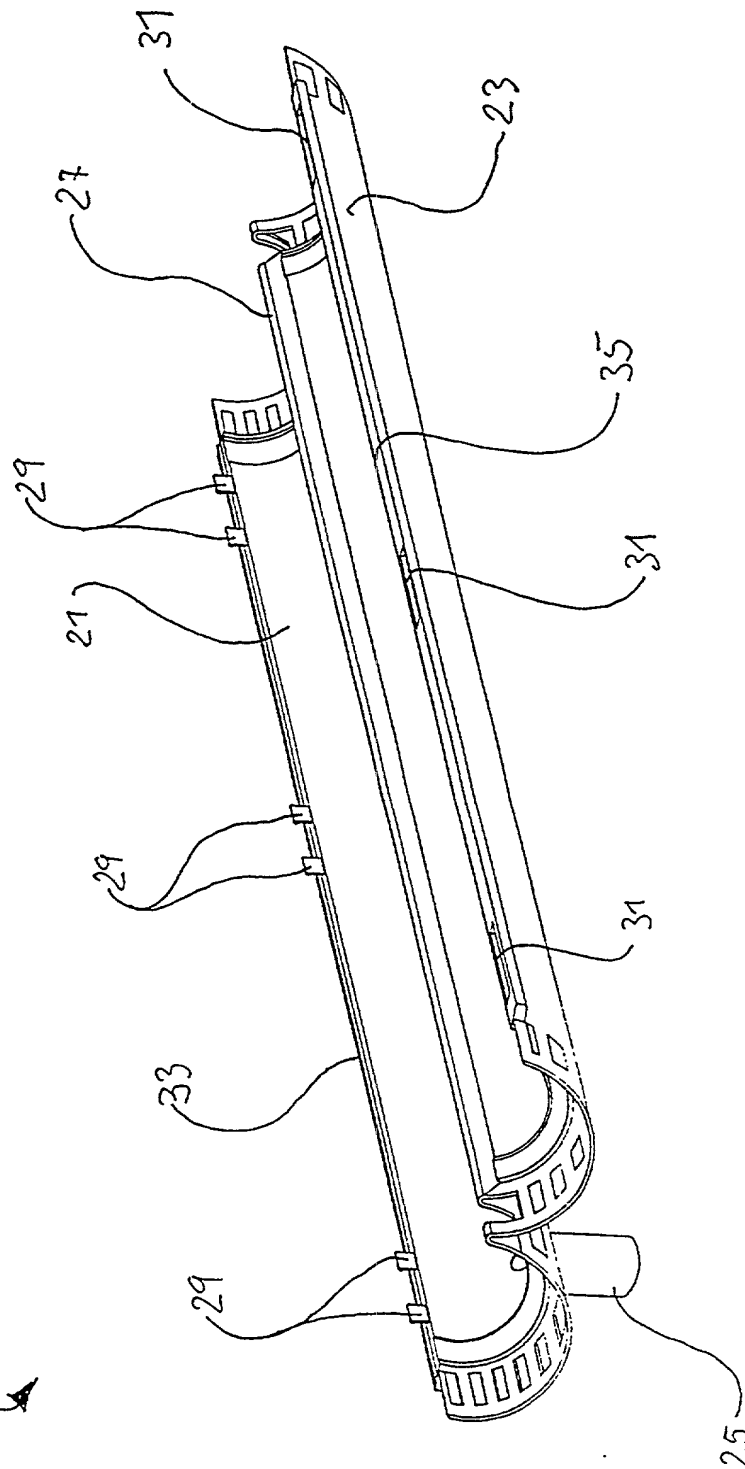


Fig. 1

Species	Sex	Age	Weight (g)	Length (mm)	Wing (mm)	Tail (mm)	Culmen (mm)	Bill (mm)	Foot (mm)	Middle toe (mm)	Claw (mm)	Stomach contents
<i>Alcedo</i>	♂	Adult	12.5	110	55	45	15	15	10	10	5	Empty
<i>Alcedo</i>	♀	Adult	11.8	108	53	43	14	14	9	9	4	Small insect
<i>Alcedo</i>	♂	Adult	13.2	112	57	47	16	16	11	11	6	Small insect
<i>Alcedo</i>	♀	Adult	12.1	110	56	46	15	15	10	10	5	Small insect
<i>Alcedo</i>	♂	Adult	12.8	111	56	46	15	15	10	10	5	Small insect
<i>Alcedo</i>	♀	Adult	11.5	107	54	44	14	14	9	9	4	Small insect
<i>Alcedo</i>	♂	Adult	13.0	111	56	46	15	15	10	10	5	Small insect
<i>Alcedo</i>	♀	Adult	12.3	109	55	45	15	15	10	10	5	Small insect
<i>Alcedo</i>	♂	Adult	12.6	110	55	45	15	15	10	10	5	Small insect
<i>Alcedo</i>	♀	Adult	11.9	108	54	44	14	14	9	9	4	Small insect
<i>Alcedo</i>	♂	Adult	13.1	111	56	46	15	15	10	10	5	Small insect
<i>Alcedo</i>	♀	Adult	12.4	109	55	45	15	15	10	10	5	Small insect
<i>Alcedo</i>	♂	Adult	12.7	110	55	45	15	15	10	10	5	Small insect
<i>Alcedo</i>	♀	Adult	12.0	108	54	44	14	14	9	9	4	Small insect
<i>Alcedo</i>	♂	Adult	12.9	110	55	45	15	15	10	10	5	Small insect
<i>Alcedo</i>	♀	Adult	12.2	109	54	44	14	14	9	9	4	Small insect
<i>Alcedo</i>	♂	Adult	13.3	112	57	47	16	16	11	11	6	Small insect
<i>Alcedo</i>	♀	Adult	12.5	110	56	46	15	15	10	10	5	Small insect
<i>Alcedo</i>	♂	Adult	12.8	111	56	46	15	15	10	10	5	Small insect
<i>Alcedo</i>	♀	Adult	12.1	109	55	45	15	15	10	10	5	Small insect
<i>Alcedo</i>	♂	Adult	13.0	111	56	46	15	15	10	10	5	Small insect
<i>Alcedo</i>	♀	Adult	12.3	109	55	45	15	15	10	10	5	Small insect
<i>Alcedo</i>	♂	Adult	12.6	110	55	45	15	15	10	10	5	Small insect
<i>Alcedo</i>	♀	Adult	11.8	108	54	44	14	14	9	9	4	Small insect
<i>Alcedo</i>	♂	Adult	13.2	112	57	47	16	16	11	11	6	Small insect
<i>Alcedo</i>	♀	Adult	12.4	109	55	45	15	15	10	10	5	Small insect
<i>Alcedo</i>	♂	Adult	12.7	110	55	45	15	15	10	10	5	Small insect
<i>Alcedo</i>	♀	Adult	12.0	108	54	44	14	14	9	9	4	Small insect
<i>Alcedo</i>	♂	Adult	12.9	110	55	45	15	15	10	10	5	Small insect
<i>Alcedo</i>	♀	Adult	12.2	109	54	44	14	14	9	9	4	Small insect
<i>Alcedo</i>	♂	Adult	13.1	111	56	46	15	15	10	10	5	Small insect
<i>Alcedo</i>	♀	Adult	12.5	110	56	46	15	15	10	10	5	Small insect
<i>Alcedo</i>	♂	Adult	12.8	111	56	46	15	15	10	10	5	Small insect
<i>Alcedo</i>	♀	Adult	12.1	109	55	45	15	15	10	10	5	Small insect
<i>Alcedo</i> </												



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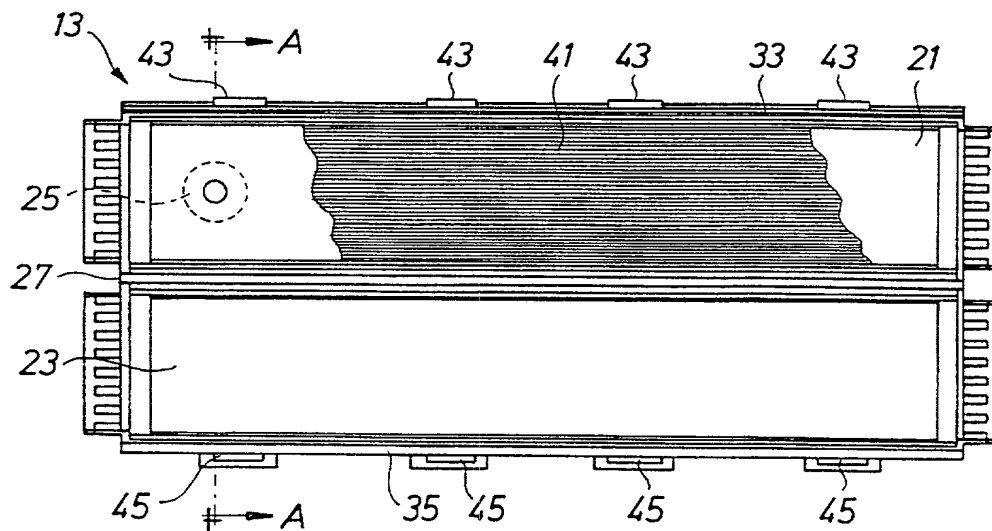


FIG. 3

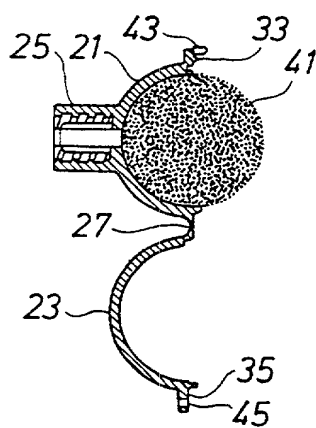


FIG. 4

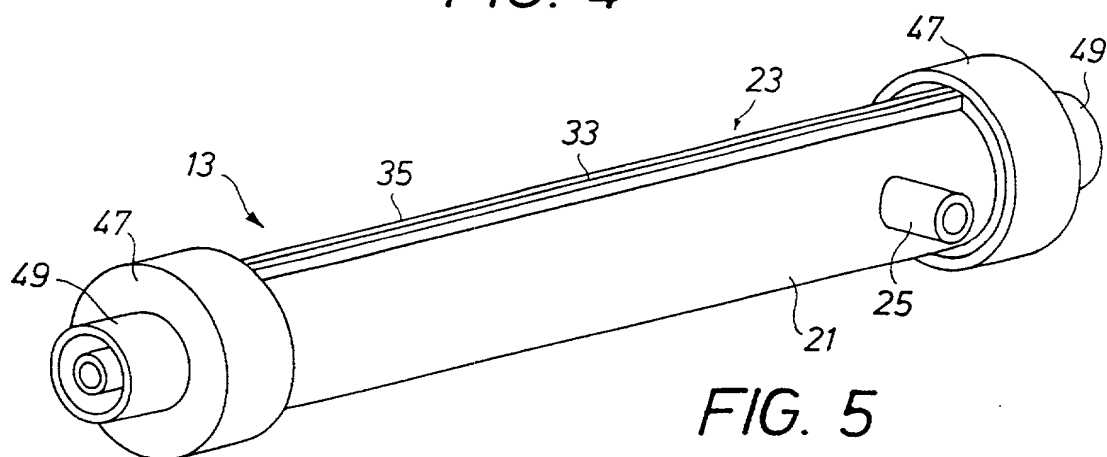


FIG. 5

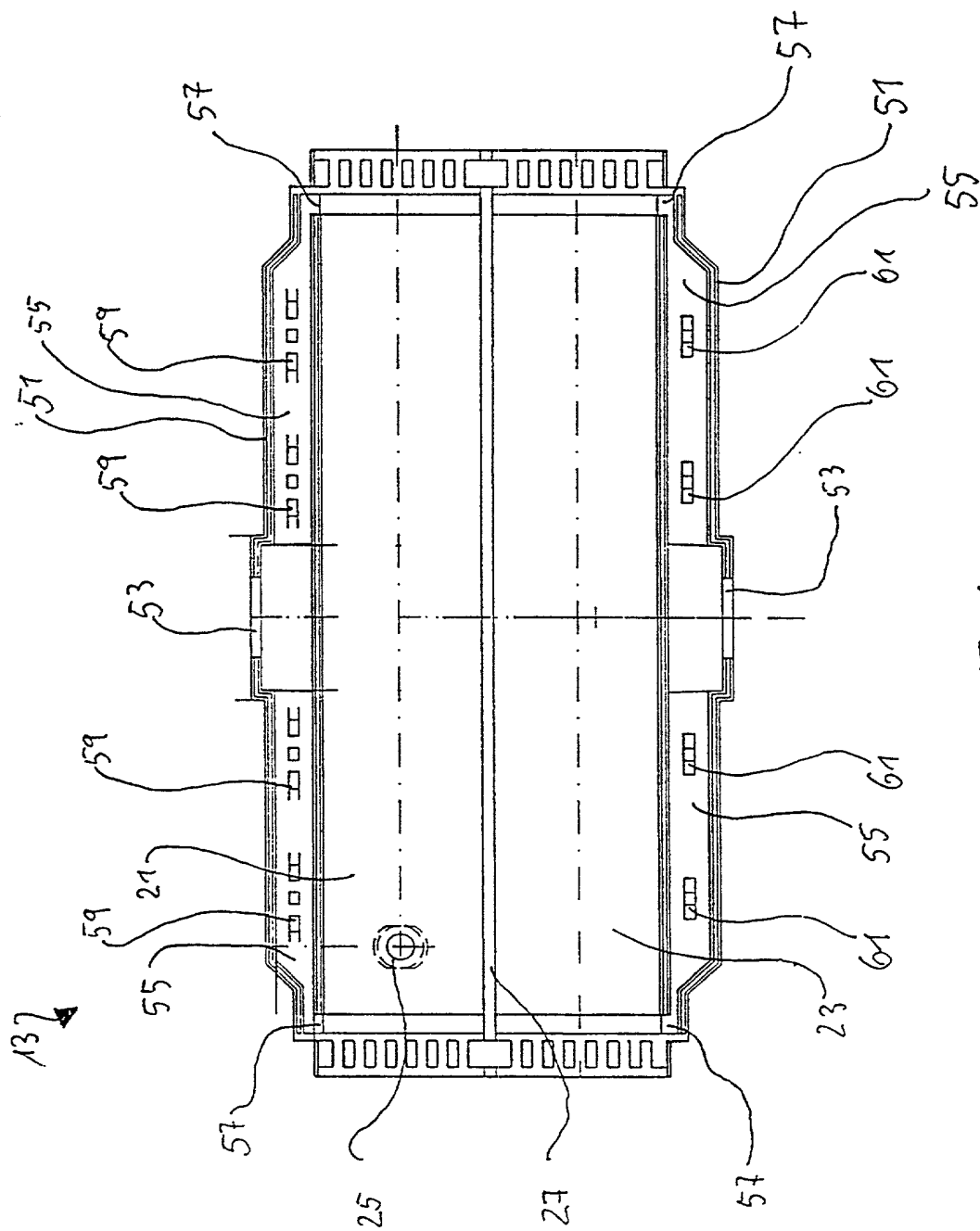


Fig. 6

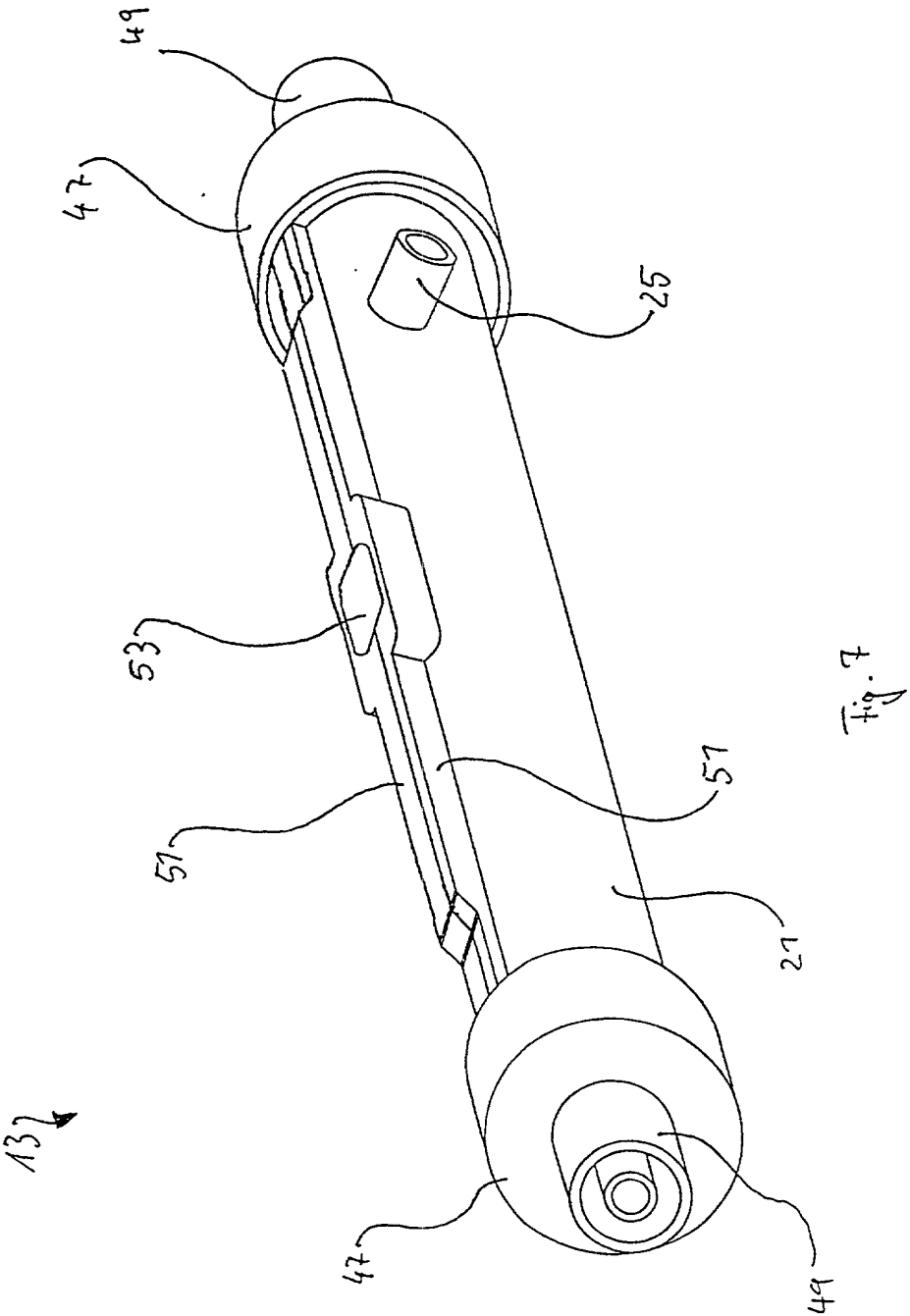


Fig. 7

DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION

ATTORNEY'S DOCKET NO.: GAMBRO 3.3-254

As a below-named inventor, I hereby declare that:

My residence, mailing address and citizenship are as stated below next to my name;

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

FILTERS AND METHOD FOR PRODUCING FILTERS

the specification of which

☐ is attached hereto

☒ was filed on January 19, 2000 as ☒ United States Application Number or PCT International Application Number PCT/IB00/00070, and was amended on January 9, 2001 (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, § 119(a)-(d) of any foreign application(s) for patent or inventor's certificate or § 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below any foreign application for patent or inventor's certificate, or any PCT international application having a filing date before that of the application on which priority is claimed:

PRIOR FOREIGN APPLICATION(S)			
COUNTRY	APPLICATION NUMBER	DATE OF FILING (month, day, year)	PRIORITY CLAIMED
Sweden /	9900283-4 /	January 29, 1999 /	YES <input checked="" type="checkbox"/> NO <input type="checkbox"/>
			YES <input type="checkbox"/> NO <input type="checkbox"/>
			YES <input type="checkbox"/> NO <input type="checkbox"/>

LISTING OF FOREIGN APPLICATIONS CONTINUED ON PAGE 3 HEREOF ☐ YES ☒ NO

I hereby claim the benefit under Title 35, United States Code, § 119(e) of any United States provisional application(s) listed below:

Application Number:

Filing Date:

Application Number:

Filing Date:

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s), or § 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT international application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

U.S. Parent Application Serial Number:

Parent Filing Date:

Parent Patent No.:

U.S. Parent Application Serial Number:

Parent Filing Date:

Parent Patent No.:

PCT Parent Number:

Parent Filing Date:

LISTING OF US APPLICATIONS CONTINUED ON PAGE 3 HEREOF: ☐ YES ☒ NO

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following registered practitioner(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith: Customer Number 000530

DIRECT ALL CORRESPONDENCE TO: Customer No. 000530

DECLARATION -- Page 2

ATTORNEY DOCKET NO. GAMBRO 3.3-254

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further, that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

1-00 Full name of sole or first inventor (given name, family name): Jürgen DANNENMAIER

Inventor's signature J. Dannenmaier Date 27.06.01

Residence: Balingen Germany Citizenship: Germany DEX

Mailing Address: Grünwaldstrasse 88, DE-72336 Balingen, Germany

2-00 Full name of second joint inventor, if any (given name, family name) Herbert RAABE

Second Inventor's signature Herbert Raabe Date 27.06.2001

Residence: Haigerloch-Stetten, Germany Citizenship: Germany DEX

Mailing Address: Beethovenweg 14, DE-72401 Haigerloch-Stetten, Germany

3-00 Full name of third joint inventor, if any (given name, family name) Manfred PIRNER

Third Inventor's signature Manfred Pirner Date 27.06.2001

Residence: Hechingen, Germany Citizenship: Germany DEX

Mailing Address: Graf-Friedrich-Weg 35, DE-72379 Hechingen, Germany

Full name of fourth joint inventor, if any (given name, family name):

Fourth Inventor's signature _____ Date _____

Residence: _____ Citizenship: _____

Mailing Address: _____

Full name of fifth joint inventor (given name, family name):

Fifth Inventor's signature _____ Date _____

Residence: _____ Citizenship: _____

Mailing Address: _____

Full name of sixth joint inventor, if any (given name, family name):

Sixth Inventor's signature _____ Date _____

Residence: _____ Citizenship: _____

Mailing Address: _____

Full name of seventh joint inventor, if any (given name, family name):

Seventh Inventor's signature _____ Date _____

Residence: _____ Citizenship: _____

Mailing Address: _____

Full name of eighth joint inventor, if any (given name, family name):

Eighth Inventor's signature _____ Date _____

Residence: _____ Citizenship: _____

Mailing Address: _____